



## Buffalo Ditch Total Maximum Daily Load Withdrawal

### **PUBLIC COMMENTS**

Public Notice  
October 12 through November 26, 2018

Missouri Department of Natural Resources  
Water Protection Program  
PO Box 176  
Jefferson City, MO 65102-0176  
800-361-4827 / 573-751-1300

## INTRODUCTION

The Missouri Department of Natural Resources placed the proposed withdrawal of the Buffalo Ditch dissolved oxygen total maximum daily load (TMDL) on a 45-day public notice and comment period from October 12 through November 26, 2018. All original comments are included here in their entirety. The Department's response to comments is available online at [dnr.mo.gov/env/wpp/tmdl/3118-buffalo-ditch-record.htm](http://dnr.mo.gov/env/wpp/tmdl/3118-buffalo-ditch-record.htm).

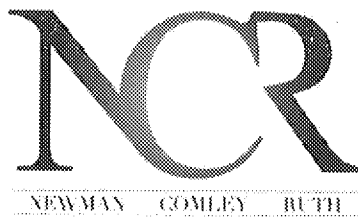
Comments were received from the following groups and individuals:

Newman, Comley & Ruth P.C.

Missouri Public Utility Alliance

Kennett Board of Public Works

JOHN T. BROOKS  
ROBERT J. BRUNDAGE  
EDWARD C. CLAUSEN  
KIMBERLY J.Z. GUTHRIE  
JOSHUA L. HILL  
CATHLEEN A. MARTIN



RYAN J. MCDANIELS  
STEPHEN G. NEWMAN  
JOHN A. RUTH  
ALICIA EMBLEY TURNER

OF COUNSEL  
MARK W. COMLEY

November 6, 2018

**VIA EMAIL**

Missouri Department of Natural Resources  
Water Protection Program  
Attn: Michael Kruse  
P.O. Box 176  
Jefferson City, MO 65102-0176  
[tmdl@dnr.mo.gov](mailto:tmdl@dnr.mo.gov)

RE: Withdrawal of the Dissolved Oxygen Total Maximum Daily Load for Buffalo Ditch

Dear Mr. Kruse:

I am writing in response to the Public Notice dated October 12, 2015<sup>8</sup> in which the MDNR proposes to withdraw the Buffalo Ditch TMDL. I am writing to support the MDNR's withdraw of this TMDL. This TMDL was hastily drafted and based upon inadequate data, and numerous errors in the scientific data and scientific methodology to prepare the wasteload allocation. This TMDL should be withdrawn and the receiving stream should be further assessed to determine whether it was actually impaired for dissolved oxygen or whether naturally low levels of dissolved oxygen occur in Buffalo Ditch which would necessitate or support a site-specific dissolved oxygen water quality criteria for this stream.

Sincerely,

NEWMAN, COMLEY & RUTH P.C.

By:

Robert J. Brundage  
[rbrundage@ncrpc.com](mailto:rbrundage@ncrpc.com)

RJB:la



*Serving Municipal Utilities*

November 21, 2018

Department of Natural Resources  
Water Protection Program  
Attn: Michael Kruse  
P.O. Box 176  
Jefferson City, MO 65102-0176

**RE: Withdrawal of the dissolved oxygen total maximum daily load for Buffalo Ditch (Water Body ID: 3118), approved on March 3, 2010.**

Dear Mr. Kruse:

The Missouri Public Utility Alliance (MPUA) is in support of the action to withdraw the Buffalo Ditch Total Maximum Daily Load (TMDL) for dissolved oxygen. The TMDL was approved by EPA to comply with the 2001 Consent Decree from the *American Canoe Association, et al. v. EPA*, No. 98-1195-CV-W. In order to comply with the consent decree deadline, the TMDL was written using data that is not reflective of the critical low flows and other local water quality conditions. The hastily written TMDL has led to unnecessarily increasing the cost burden on rate payers, the obstruction of infrastructure upgrades, and the delay of water quality improvements due to impracticable wasteload allocations. The TMDL withdrawal provides the community-owned utility with well-deserved relief from wasteload allocations that do not meet the standard of reproducibility.

MPUA supports the Missouri Department of Natural Resources' decision to re-categorize the water body impairment as Category 5 for inclusion on the Missouri 303(d) list of impaired waters. We understand this action allows for commonsense, innovation, and sound scientific practices to be implemented within the development of water quality criteria protective of the designated uses within the Buffalo Creek watershed.

We appreciate your past and continued support of our member utility – Kennett City Light, Gas and Water - on this issue. MPUA is a nonprofit service organization representing over 110 municipally-owned utilities in Missouri. Please do not hesitate to contact myself or Ewell Lawson, VP of Governmental Affairs and Member Relations, with any questions or concerns.

Sincerely,

A handwritten signature in black ink, reading "Lacey Hirschvogel". The signature is fluid and cursive, with the first name "Lacey" being more prominent.

Lacey Hirschvogel  
Environmental and Public Policy Coordinator  
MPUA | Missouri Association of Municipal Utilities

cc: David Wilkins, Kennett Board of Public Works



# Kennett Board Of Public Works

P.O. BOX 40 • KENNETT, MISSOURI 63857-0040 • (573) 888-5366 • FAX (573) 888-3312

Department of Natural Resources  
Water Protection Program  
Attn: Michael Kruse  
PO Box 176  
Jefferson City, MO 65102-0176  
[Tmdl@dnr.mo.gov](mailto:Tmdl@dnr.mo.gov)

November 26, 2018

Re: Comments on Buffalo Ditch TMDL Proposed Withdrawal

Dear Mr. Kruse and others To Whom It May Concern:

On behalf of the Kennett Board of Public Works (dba City Light Gas and Water) ("CLGW"), I am writing in regard to the Missouri Department of Natural Resources ("MDNR" or "the Department") proposed withdrawal of the Total Maximum Daily Load ("TMDL") for the Buffalo Ditch (WBID 3118) ("Proposed Withdrawal"). CLGW appreciates the opportunity to comment on the Proposed Withdrawal. Further, CLGW fully supports MDNR's determination to withdraw the Buffalo Ditch TMDL.

As noted by the Department in the Proposed Withdrawal, CLGW requested MDNR review the Buffalo Ditch TMDL administrative record. The basis of CLGW's request was the City's longstanding position that the Buffalo Ditch TMDL, which contains wasteload allocations for the City's wastewater treatment plant for Total Nitrogen, Total Phosphorous, Total Suspended Solids and Biochemical Oxygen Demand in an attempt to reduce Dissolved Oxygen ("DO") concentrations in the Buffalo Ditch, is not legally justified based on the following:

- Natural background conditions prevent attainment of Missouri's DO standard in the Buffalo Ditch;
- EPA's TMDL model (QUAL2K), significant reductions in sediment oxygen demand from nonpoint sources are required to achieve Missouri's DO standard in the Buffalo Ditch;
- The QUAL2K model indicates significant nonpoint source reductions in nutrients and TSS during critical low-flow conditions are required to achieve Missouri's DO standard in the Buffalo Ditch;
- The TMDL does not include reasonable assurances that nonpoint source reductions will be achieved; and
- Wasteload allocations were not established with the QUAL2K model under low-flow conditions.

These arguments were advanced to EPA in reports prepared by the City's experts at HDR Engineering for the Buffalo Ditch TMDL. While much of the Department's underlying rationale appears to align with the information in the City Reports, both documents are attached and incorporated herein, as the reasons identified in the City Reports supplement and further support the Proposed Withdrawal. For instance, MDNR focuses on technical issues identified with the QUAL2K model, while the City Reports include a

more detailed discussion of the extent of nonpoint source reductions that would be necessary to achieve Missouri's DO standard.

CLGW requests MDNR review the City Reports and include the additional reasoning supporting withdrawal of the Buffalo Ditch TMDL for purposes of creating a full and comprehensive record. That said, CLGW appreciates the tremendous amount of work that has gone into reviewing and re-evaluating the Buffalo Ditch TMDL, as well as MDNR's commitment to resolve technical difficulties with the Buffalo Ditch TMDL before the implementation process begins. CLGW agrees that "the wasteload and load allocation targets established in the Buffalo Creek TMDL will not result in attainment of the applicable DO criterion" and supports the Proposed Withdrawal and recategorization of the Buffalo Ditch as a Category 5 water.

Again, CLGW appreciates the Department's work and the opportunity to comment on the Proposed Withdrawal. If you have any questions, I can be reached at the contact information below. Thank you.

Sincerely,



David W. Wilkins, Superintendent of Utilities  
Kennett Board of Public Works  
PO Box 40  
Kennett, MO 63857  
573-717-2003

Attachments

Supplemental Explanations of the Buffalo Ditch TMDL by John Stober and Andrew Thuman  
regarding

*City of Kennett, Missouri v. United States Environmental Protection Agency*

Case No.: 1:14-cv-00033-SNLJ

June 10, 2016

## I. Overview

In January 2016, HDR prepared a report providing our review and critique of the Buffalo Ditch Total Maximum Daily Load (TMDL). That report, hereinafter referred to as the “Expert Report”, was submitted along with the City of Kennett’s Motion for Summary Judgment. The Expert Report relied solely upon the administrative record of the Buffalo Ditch TMDL to make the following general conclusions:

- ∞ Natural “background” conditions prevent attainment of Missouri’s dissolved oxygen standard of 5 mg/L in Buffalo Ditch.
- ∞ Based upon the U.S. Environmental Protection Agency’s (USEPA) TMDL model (QUAL2K), significant reductions in sediment oxygen demand (SOD) originating from nonpoint sources are required to achieve Missouri’s dissolved oxygen standard of 5 mg/L in Buffalo Ditch.
- ∞ Based upon USEPA’s TMDL model, significant nonpoint source reductions in nutrients and total suspended solids during critical low flow conditions are required to achieve Missouri’s dissolved oxygen standard of 5 mg/L in Buffalo Ditch.
- ∞ The TMDL does not include adequate reasonable assurances that nonpoint source reductions will be achieved.
- ∞ Wasteload allocations were not established with the QUAL2K water quality model under critical low flow conditions, as defined in the TMDL.

The USEPA’s response to the City’s motion differed with several aspects of the Expert Report including the conclusions summarized above. However, USEPA’s response did not consider several key facts that are established in the administrative record. Chief among these is the fact that the QUAL2K water quality model was critical to establishing wasteload allocations and determining that reductions in nutrients and biochemical oxygen demand (BOD) were necessary to meet Missouri’s dissolved oxygen standard of 5 mg/L in Buffalo Ditch (Administrative Record at 0000065).

While this report is largely structured around conclusions from the first Expert Report, the purpose of this report is only to provide additional explanation to address USEPA’s response to the City’s motion where necessary. To this end, this report is structured as follows:

- ∞ Regional Dissolved Oxygen Conditions – This section addresses USEPA assertions suggesting that low dissolved oxygen is not a widespread regional condition. Data from the administrative record is used to demonstrate that these regional conditions do contribute to dissolved oxygen impairments of nearby waters that Missouri considers high quality.
- ∞ TMDL Tools for Generating Wasteload Allocations and Demonstrating Compliance with Water Quality Standards – This section addresses USEPA’s assertion regarding the limited role of the QUAL2K model and the asserted importance of the load duration



curve (LDC) approach. Information from the administrative record is used to document the important role that the QUAL2K model played in establishing TMDL wasteload allocations and demonstrating that the TMDL load reductions will comply with Missouri dissolved oxygen standard. In addition, the administrative record is used to demonstrate that there is no quantitative link between the LDC load allocations and dissolved oxygen standard compliance. Therefore, the TMDL does not demonstrate water quality standards attainment without the linkages between pollutant loading and dissolved oxygen provided by the QUAL2K model.

- ∞ Critical Low Flow Conditions – This section addresses contradictions in the TMDL and USEPA’s response with respect to critical low flow conditions and how these conditions were applied in the TMDL. Specifically, this section documents how critical conditions as defined in the TMDL (i.e., zero nonpoint source flow) were applied to the nonpoint source load allocations, but not within the QUAL2K water quality model. In addition, this section calls attention to the inconsistencies in USEPA’s expert testimony with respect to this critical TMDL component.
- ∞ Sediment Oxygen Demand and the Role of Nonpoint Sources – This section addresses USEPA’s comments by providing additional documentation from the administrative record that significant reductions in assigned sediment oxygen demand from nonpoint sources are required to achieve Missouri’s dissolved oxygen standard of 5 mg/L in Buffalo Ditch at critical low flow conditions.
- ∞ Nonpoint Source Reductions and Reasonable Assurances – This section addresses issues with the assumptions that form the basis for USEPA’s assertion that nonpoint source reductions and reasonable assurances are not required for critical low flow periods.

Each of these sections supports the overall conclusion that the TMDL was not adequately established to implement Missouri’s dissolved oxygen water quality standard in Buffalo Ditch.

## **II. Regional Dissolved Oxygen Conditions**

According to the Buffalo Ditch TMDL, “low dissolved oxygen is an issue in Buffalo Ditch both upstream and downstream of the Kennett Wastewater Treatment Plant” and “due to issues regarding low dissolved oxygen as a natural background condition, the department may develop revised dissolved oxygen criteria for Buffalo Ditch and similar streams during the next Triennial Review for Water Quality Standards” (Administrative Record at 0000038-0000039). As documented in the Expert Report at pages 10-11, the inability of Buffalo Ditch and other streams in the surrounding region to attain Missouri’s dissolved oxygen standard of 5 mg/L is empirically evident based on data collected by the Missouri Department of Natural Resources (MDNR) and USEPA from both reference sites and sites located upstream of the Kennett Wastewater Treatment Plant (WWTP).

USEPA does not refute that low dissolved oxygen is pervasive in the region of Buffalo Ditch, but they do assert that other perennially-flowing streams in the region meet dissolved oxygen (DO) water quality standards. Specifically, USEPA states the following:

“Maple Slough Ditch in Mississippi County, also located in the proximity of Buffalo Ditch, is a perennial stream. This stream has a gradient of 0.000232 and is not impaired by low DO.”(Declaration of Dr. Steven Wang, p.25)

The statement that Maple Slough is not impaired for dissolved oxygen is inconsistent with the administrative record. USEPA has considered Maple Slough Ditch in Mississippi County impaired (i.e., 303(d) listed) for low dissolved oxygen since 2010 (Administrative Record at 0000300). Additionally, dissolved oxygen data collected in the mornings of July 8-9, 2003 and August 12-13, 2003 at Ragland Slough (another nearby perennially flow ditch) ranged from 1.2 to 2.1 mg/L (Administrative Record at 0003942). Ragland Slough, which is also known as Pole Cat Slough, was selected as a reference station during the 2003 wasteload allocation study for the Kennett WWTP (Administrative Record at 0003902).

USEPA also asserts that the impaired segment of Buffalo Ditch is limited to the three-mile segment located downstream of the Kennett WWTP as noted below:

- ∞ “Nor does the City dispute that the segment of Buffalo Ditch that did not meet the water quality standards for dissolved oxygen is the three mile stretch directly downstream of the KWTP” (EPA’s Memo in Response to the Motion for Summary Judgment, p.20)
- ∞ “the data, modeling, and science all establish that: . . . (b) the impaired area for dissolved oxygen is directly below the KWTP . . . “ (EPA’s Memo in Response to the Motion for Summary Judgment, p.23)
- ∞ “As part of the TMDL for Buffalo Ditch, MDNR found that State’s classified segment of Buffalo Ditch is 18.0 miles in length and that the area where dissolved oxygen water quality standard is not attained is within the three-mile section immediately downstream of the Kennett Wastewater Treatment Plant (“KWTP”)” (Defendant’s Statement of Uncontroverted Material Facts, p.6)

However, USEPA apparently did not consider data collected since Buffalo Ditch was initially listed as impaired in 1994, most of which were collected by USEPA contractors. Data collected since that time demonstrates that the Missouri dissolved oxygen standard of 5 mg/L is not attained outside of the three-mile segment located downstream of the Kennett WWTP as evident below:

- ∞ 39% of the continuous dissolved oxygen data collected 0.8 miles upstream from the Kennett WWTP at Site BU-2 from May 20-23, 2008 was below 5 mg/L (Administrative Record at 0004086).

- ∞ Dissolved oxygen data collected 0.9 miles upstream of the Kennett WWTP at site M1 in the mornings of July 8 and August 12, 2003 ranged from 1.0 to 1.2 mg/L (Administrative Record at 0003940).
- ∞ Dissolved oxygen data collected 4.4 miles downstream of the Kennett WWTP in the mornings of July 8-9, and August 12-13, 2003 ranged from 1.8 to 3.4 mg/L (Administrative Record at 0004057).
- ∞ Dissolved oxygen data collected 4.4 miles downstream of the Kennett WWTP in the morning of May 21, 2008 was 3.9 mg/L (Administrative Record at 0000030).
- ∞ The calibrated QUAL2K model which represents existing water quality conditions predicts dissolved oxygen levels less than the Missouri dissolved oxygen standard both upstream of the Kennett WWTP and at distances greater than 3 miles downstream from the Kennett WWTP (Administrative Record at 0000070).

The fact that dissolved oxygen standards are not attained upstream of the Kennett WWTP and in other nearby perennially-flowing reference streams demonstrate that regional conditions outside the influence of the City significantly contribute to non-attainment of the Missouri dissolved oxygen standard.

### **III. TMDL Tools for Generating Wasteload Allocations and Demonstrating Compliance with Water Quality Standards**

The load duration curve approach and QUAL2K water quality model were the primary tools used in the development of the TMDL. The Expert Report asserts that the QUAL2K model was critical to the development of wasteload allocations and demonstrating compliance with Missouri's dissolved oxygen standard. However, USEPA stated that the City's experts are mistaken and that the LDC, not the QUAL2K model, was used for this purpose as asserted below:

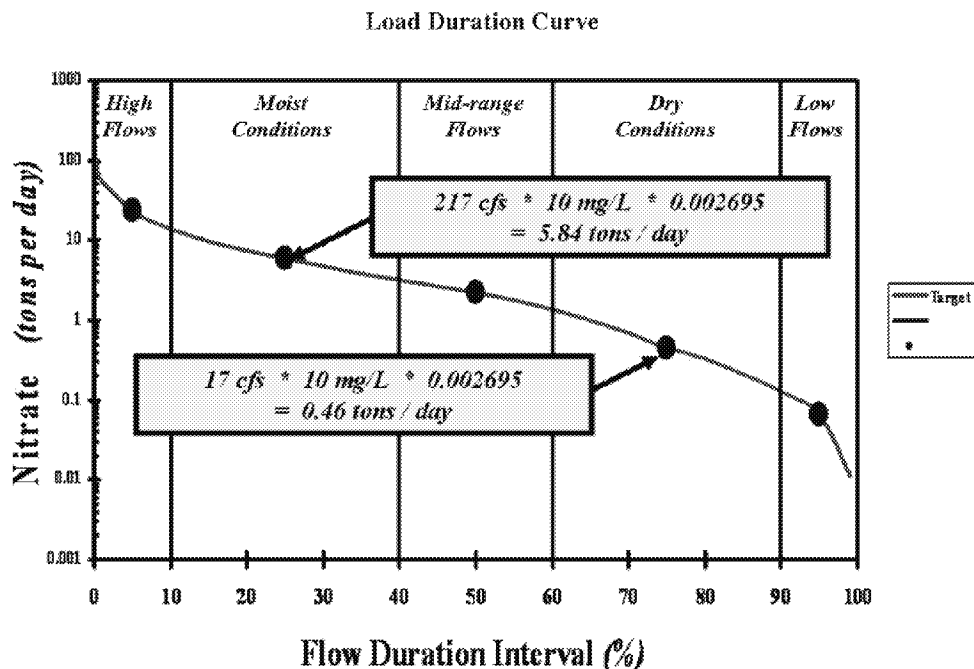
“In fact, the City's challenge to EPA's conclusion is not even based on the data and information EPA considered. *EPA's determination that the assigned loads are designed to meet water quality standards designated for Buffalo Ditch is based on application of the Load Duration Curve models.* Yet the City never challenges either the use of the Load Duration Curve models or their conclusions regarding Buffalo Ditch. Instead, every time the City refers to modeling for Buffalo Ditch, it refers to the QUAL2K model, which was not used to generate the loads in the TMDL. Indeed, the City affirmatively declares that EPA used the 'QUAL2K model to formulate the Buffalo Ditch TMDL,' which is *patently incorrect* (emphasis added).” (USEPA's Memo in Response to the Motion for Summary Judgment, p.24)

The issue of whether the LDC approach or QUAL2K model was used to establish wasteload allocations and demonstrate compliance with Missouri's dissolved oxygen standard is critical. If USEPA is correct that the QUAL2K model was not used for this purpose, then USEPA has

established no link between the assigned TMDL loadings and the dissolved oxygen standard. If, however, USEPA is incorrect as is evident by the administrative record, then issues identified in the Expert Report remain valid. Either way, the USEPA has not met its statutory obligation to demonstrate compliance with the dissolved oxygen water quality standard. Further discussion below demonstrates from the administrative record that: 1) the LDC does not demonstrate compliance with the dissolved oxygen water quality standard and 2) the QUAL2K model was the tool used to establish wasteload allocations and demonstrate compliance with Missouri's dissolved oxygen standard.

### A. Role of Load Duration Curves in TMDL

To provide context for USEPA's assertions regarding the use of LDCs, it is important to understand how LDCs are developed and the limitations of this approach. According to USEPA guidance, "LDCs are graphical analytical tools used to illustrate the relationships between stream flow and water quality and assist in decision making regarding this relationship" (Administrative Record at 0000459). The LDC is developed "by multiplying stream flow with the numeric water quality target (usually a water quality criterion) and a conversion factor for the pollutant of concern" (Administrative Record at 0000436). In the example below, the LDC is based on a numeric water quality target for nitrate of 10 mg/L (Figure 1). In this example, the water quality target is the numeric water quality standard for nitrate to protect drinking water supplies. Therefore, the numeric water quality standard can be directly applied within the LDC tool since there are no instream mechanisms that influence the level of nitrate within the receiving water.



**Figure 1.** Example of Load Duration Curve (Administrative Record at 0000478)

It is important to distinguish the numeric water quality target from the loading capacities expressed in a TMDL. “Numeric water quality targets are translated into TMDLs through the loading capacity” (Administrative Record at 0000443). While LDCs may be used to derive the loading capacity under different flow conditions, LDCs are not used to set the numeric water quality target. Per USEPA guidance, the water quality target is as follows:

“The numeric water quality target represents the quantitative value used to measure whether or not the applicable water quality standard (WQS) is attained. Generally, the target is the water quality criterion contained in the WQS for the pollutant of concern. . . . Because the water quality criterion is crucial in the development of the loading capacity, ***the absence of numeric criteria poses challenges (e.g., sediment, nutrients)***. As efforts continue to develop and adopt numeric sediment and/or nutrient criteria, practitioners should evaluate whether an appropriate interim or site-specific, numeric endpoint can be identified prior to using the duration framework for TMDLs. ***Otherwise, alternative analytical methods should be explored*** (emphasis added).” (Administrative Record at 0000442)

In the case of the Buffalo Ditch TMDL, there are no numeric water quality criteria for total phosphorus (TP), total nitrogen (TN), total suspended solids (TSS), or biochemical oxygen demand (BOD). Therefore, the QUAL2K water quality model was necessary to confirm whether numeric water quality targets for each parameter were set at a level considered protective of Missouri’s dissolved oxygen standard (Administrative Record at 0000005-0000006 and 0000065). The LDC was not used, nor is this tool intended to be used, for establishing the numeric water quality target or confirming whether the targets result in attainment of standards.

LDCs are typically used to account for seasonal variation as required in statute at 33 U.S.C. §1313(d)(3). As stated in the TMDL, “Load duration curves represent the allowable pollutant load under different flow conditions and across all seasons” (Administrative Record at 0000038). In effect, the LDC translates the water quality targets into a loading capacity over a range of flow regimes. Combined with instantaneous loads calculated from ambient water quality data, LDCs also provide a useful tool for assessing patterns of impairment. “Impairments observed in the low flow zone typically indicate the influence of point sources, while those further left generally reflect potential nonpoint source contributions” (Administrative Record at 0000444). This framework “provides a reasonable way to define allocations because it allows adjustments, which reflect differences in the types of sources that may be dominant under various flow conditions” (Administrative Record at 0000446).

While well suited for certain purposes, USEPA guidance recognizes that the LDC approach is not applicable in all circumstances. Specifically, USEPA recommends that “water quality analysts should assess the appropriateness of using this framework to develop a particular TMDL” and that “[p]ractitioners should also consider the suitability of using it as the sole basis for assessment versus supplementing its use with other analytical tools, such as ***water quality***

*models* (emphasis added)” (Administrative Record at 0000451). In the case of the Buffalo Ditch TMDL, the LDCs were supplemented with the QUAL2K model to demonstrate water quality standard attainment and develop the BOD wasteload allocation. As such, the LDCs did not serve as the sole basis for assessment as the QUAL2K water quality model was used “to determine the reduction in nutrients and biochemical oxygen demand necessary to meet the dissolved oxygen standard (5.0 mg/L) downstream of the plant discharge” (Administrative Record at 0000065).

In discussing the appropriateness of the LDC approach, USEPA guidance explains that an underlying premise is correlation of water quality impairments to flow conditions. USEPA notes that the “duration curve alone does not consider fate and transport mechanisms, which may vary depending on watershed or pollutant characteristics” (Administrative Record at 0000451). USEPA goes on to recommend “using a separate analytical tool to develop a TMDL when factors other than flow significantly affect a water body’s loading capacity” (Administrative Record at 0000451). In the case of dissolved oxygen, a water body’s loading capacity is determined by a number of processes other than flow (Administrative Record at 00001236-0001260 and 0001307-0001778). Therefore, the TMDL states that based on QUAL2K’s “proven ability to simulate the processes important to dissolved oxygen conditions within streams”, it was selected for generating “*the relationship between the source loadings of biochemical oxygen demand and nutrients on dissolved oxygen* (emphasis added)” (Administrative Record at 0000033).

Another premise of the LDC approach “is that applicable water quality standards are protective of the designated use(s) over the entire flow regime” (Administrative Record at 0000451). In the case of the Buffalo Ditch TMDL, the “applicable water quality standards” applied to the LDC are the ecoregional water quality targets for TP, TN, and TSS. However, the QUAL2K model was required to demonstrate that the ecoregion values will result in attainment of the Missouri dissolved oxygen standard, and this model was used at the targeted low flow, critical condition. Therefore, as discussed in USEPA guidance, the utility of the LDC is limited at the low flow, critical condition:

“A possible scenario of a flow provision is where criteria explicitly state applicability at the 7Q10 flow. This reduces the importance of the criteria during the remaining flows (e.g., moderate to wet weather). In this example, the utility of the duration curve method is better suited as a diagnostic tool identifying magnitude and frequency of concerns across all flows.” (Administrative Record at 0000451)

In summary, the role of LDCs in developing the Buffalo Ditch TMDL was limited. As discussed above, LDCs do not form the basis for numeric water quality targets; rather, it is the other way around. LDCs are simply the mass-based representation of the water quality target under different flow conditions. Furthermore, USEPA cautions against the use of LDCs as the sole basis for assessment, particularly when factors other than flow affect a water body’s loading capacity. As further discussed below, the QUAL2K model, and not the LDCs, was used for

establishing WLAs and demonstrating compliance with Missouri's dissolved oxygen standard. Lastly if USEPA's response is correct and the QUAL2K model was not used for this purpose, then there is no link between the assigned TMDL loadings (i.e., wasteload and load allocations) and the Missouri dissolved oxygen standard using the LDC approach alone.

## **B. Role of QUAL2K in TMDL**

USEPA's response documents assert that the QUAL2K water quality model had a limited role in the development of the TMDL and was only used to "estimate BOD water quality based effluent limits for the [Kennett WWTP]" (USEPA's Memo in Response to the Motion for Summary Judgment, p.13). However, the TMDL itself contradicts these assertions and highlights the importance of the QUAL2K model in the development of the TMDL:

- ∞ "Another essential component of developing a TMDL is establishing a relationship between the source loadings and resulting water quality. *For this TMDL, the relationship between the source loadings of BOD and nutrients on DO is generated by the water quality model QUAL2K* (emphasis added)." (Administrative Record at 0000005)
- ∞ "*The WLA for BOD was derived from the QUAL2K modeling that resulted in meeting WQS* (emphasis added)." (Administrative Record at 0000008)
- ∞ "QUAL2K is supported by EPA and [has] been used extensively for TMDL development and point source permitting issues across the country, especially for dissolved oxygen studies. QUAL2K is well accepted within the scientific community because of its proven ability to simulate the processes important to dissolved oxygen conditions within streams." (Administrative Record at 0000033)
- ∞ "For this TMDL, *the relationship between the source loadings of biochemical oxygen demand and nutrients on dissolved oxygen is generated by the water quality model QUAL2K* (emphasis added)." (Administrative Record at 0000033)
- ∞ "Once the QUAL2K model was setup and calibrated for Buffalo Ditch, a series of scenarios were run to *evaluate the pollutant load reductions needed to achieve the dissolved oxygen criteria* (emphasis added)." (Administrative Record at 0000033)
- ∞ "The load allocations are provided in Tables 7 through 9 and were calculated based on the total of all headwater and lateral inflow loads used in the QUAL2K model for the allocation scenario model run." (Administrative Record at 0000034)
- ∞ "Simulations were performed [in the QUAL2K model] to determine the *reduction in nutrients and biochemical oxygen demand necessary to meet the dissolved oxygen standard (5.0 mg/l)* downstream of the plant discharge (emphasis added)." (Administrative Record at 0000065)

As evident from above, the QUAL2K water quality model was critical in demonstrating that the nutrient and TSS water quality targets are protective of Missouri's dissolved oxygen standard.

However, USEPA disputes this by contending that the ecoregional values used to set the water quality targets inherently demonstrate compliance:

“To measure whether DO is attained, MDNR used the ecoregion reference nutrient values to set the quantitative water quality values. MDNR also used the same methodology to calculate the ecoregional TSS target. These water quality targets represent conditions of surface waters that are minimally impacted by human activities and protective of aquatic life and recreational uses” (Declaration of Dr. Steven Wang, p.10)

USEPA suggests that use of ecoregional nutrient values is equivalent to measuring whether dissolved oxygen is attained. However, neither the LDCs or ecoregion reference nutrient values provide a quantitative link to the Missouri dissolved oxygen standard. In the Buffalo Ditch TMDL, the ecoregion reference nutrient values used in the LDCs are adjusted USEPA nutrient criteria recommendations for rivers and streams in ecoregion X. However, these recommendations have not been promulgated into Missouri’s water quality standards and should not be directly applied within TMDLs without a demonstration that they protect water quality.

More importantly, the ecoregion reference nutrient values do not ensure compliance with the MDNR dissolved oxygen standard. Rather, the values were recommended by USEPA to “generally represent nutrient levels that protect against the adverse effects of nutrient overenrichment.” (EPA *Ambient Water Quality Criteria Recommendations, Rivers and Streams in Nutrient Ecoregion X*, p. iv, Administrative Record at 0000733-0000872). Further in the USEPA Guidance Document *Nutrient Criteria Technical Guidance Manual, Rivers and Streams*, it is stated that:

***“unfortunately, broad predictive relationships do not exist between nutrient concentration and algal/macrophyte biomass, DO, or pH.*** However, relationships could be developed for individual streams and rivers. Nevertheless, without inclusion of other factors that affect DO and pH (such as exchange with the atmosphere for specific stream systems), a biomass limit to prevent low DO (e.g., <5 mg/L) cannot be determined from any existing relationship (emphasis added).” (Administrative Record at 0006532-0006784)

The statement that relationships can be developed for individual streams and rivers is a clear indication of how water quality models, such as QUAL2K, are intended to be used. The QUAL2K model developed as part of the TMDL is the only analytical tool in the USEPA record that provides the necessary linkage between nutrients, BOD, TSS, and dissolved oxygen. Therefore, the merits of using the QUAL2K model to link nutrient load reductions to demonstrating compliance with the Missouri dissolved oxygen standard are justified.

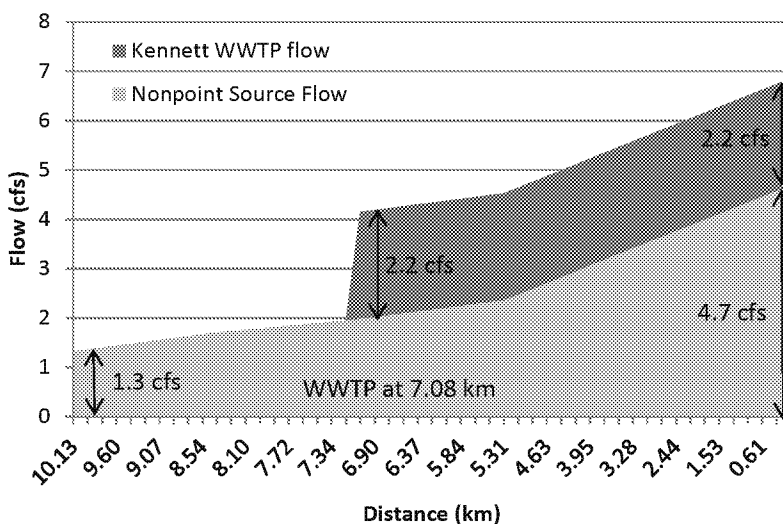
Because the QUAL2K model was in fact used in the TMDL to set wasteload allocations and for demonstrating compliance with Missouri’s dissolved oxygen standard, the model must take into



account critical conditions. Additionally, the TMDL's load allocations and reasonable assurances must take into account nonpoint source load reductions included within the QUAL2K model. These issues are further discussed in subsequent sections below.

#### IV. Critical Low Flow Conditions

The City's Expert Report documented that flow conditions applied in the QUAL2K model are not consistent with the critical low flow conditions defined in the TMDL. Whereas the TMDL specifies that during critical low flow conditions "there is effectively no flow from nonpoint sources" (Administrative Record at 0000034), the QUAL2K model assigned nonpoint source flows ranging from 1.3 cubic feet per second (cfs) entering the ditch from upstream to an additional 3.4 cfs entering the ditch along its modeled length (Figure 2). Relative to the Kennett WWTP flow rate of 2.2 cfs, modeled nonpoint source flows accounted for the majority of flow throughout most of Buffalo Ditch (Administrative Record at 0005057).



**Figure 2.** QUAL2K Model Flows (Figure 7 in the City's Expert Report, p.17)

USEPA's response does not dispute that flows applied to the QUAL2K model are inconsistent with how critical low flows are defined in the TMDL. However, USEPA experts disagree with respect to how critical low flow should be defined. On the one hand, USEPA asserts critical low flow is effectively zero as documented below:

- ∞ "At the critical condition used for WLA analysis, the stream is effluent dominated. Under low flow critical conditions, dischargers provide effluent flow that are necessary to support aquatic life without the benefit of dilution from natural baseflow."  
(Declaration of Tabatha Adkins, p.9)
- ∞ "The critical flow at the watershed outlet was defined as the 7Q10 [(lowest 7-day average flow that occurs once every 10 years)] which translates to approximately 0.057

cubic feet per second based on the modeled flow calculation . . . As a result during critical low flow conditions, when there is effectively no flow from nonpoint sources, the LA for all targeted pollutants is zero pounds per day.” (Declaration of Tabatha Adkins, p.10)

- ∞ “At critical low flow conditions, Buffalo Ditch is effluent dominated with effectively no flow from nonpoint sources.” (Declaration of Tabatha Adkins, p.12)
- ∞ “Critical low flow from nonpoint sources of nitrogen, phosphorus and suspended solids is just a fraction of the discharge of that below the KWTP, and thus there is no basis to assign nonpoint load in low flow conditions.” (USEPA’s Memo in Response to the Motion for Summary Judgment, p.22).

On the other hand, USEPA’s expert hydrologist, Dr. Steven Wang, states that flow values used in the QUAL2K model are in fact representative of critical low flow conditions. Dr. Wang notes the following:

“Three USGS gages located near Buffalo Ditch were used to estimate the 7Q10 (the lowest 7-day average flow that occurs once every 10 years). Based on the result of this flow analysis, the 7Q10 values ranged from 0.35 ft<sup>3</sup>/s to 1.10 ft<sup>3</sup>/s (Table 5). The flow values used as headwater (upstream) boundary condition for the [QUAL2K] model was 1.31 ft<sup>3</sup>/s. This value is comparable to the 7Q10 flow range.” (Declaration of Dr. Steven Wang, p.10)

The critical condition flow rate (i.e., 7Q10 critical low flow) documented by Dr. Wang (i.e., 0.35 to 1.10 cfs) is over 6 to nearly 20 times greater in magnitude than the 7Q10 value documented in the Declaration of Tabatha Adkins at the watershed outlet (i.e., 0.057 cfs). Dr. Wang justifies the higher 7Q10 value as follow:

- ∞ Quoting from *The Fishes of Missouri*, Pflieger (1975): “The sands and gravels underlying the lowlands act as a vast reservoir for water that falls as rain or snow. This water is slowly released into the ditches and as a result, their flow is very constant.” (Declaration of Dr. Steven Wang, p.12)
- ∞ Referencing a USGS study of the Lower Mississippi Region, Summary Appraisals of the Nation’s Ground-Water Resources – Lower Mississippi Region, U.S. Geological Survey Professional Paper 813N: “Flow during dry weather conditions was likely derived from groundwater seeping into Buffalo Ditch, as little rainfall occurred prior to sampling and the Bootheel region is known to have shallow water table.” (Declaration of Dr. Steven Wang, p.21)
- ∞ “During the critical conditions the watershed and Buffalo Ditch receives very little or no rainfall and thus the diffuse nonpoint source flow reflects shallow groundwater-derived flow and, potentially, irrigation return flow, as indicated by the U.S. Geological Survey.” (Declaration of Dr. Steven Wang, p.22)

- ∞ “The groundwater in the modeled reaches did contribute to sustaining the flow during the dry conditions as Buffalo Ditch lies in the flood plain between the Mississippi and St. Francis rivers.” (Declaration of Dr. Steven Wang, p.23)

USEPA asserts that discrepancies in flow between the QUAL2K model and the TMDL are not an issue because the QUAL2K model did not form the basis for their approval of the TMDL as noted below:

“EPA’s approval of the TMDL was based on the load duration curve model, which establishes loading capacity at several flow regimes, many of which consider varying levels of flow contribution from nonpoint sources. The low flow or critical condition under this model included only minimal to non-existent flow contributions from nonpoint sources. To the extent the City’s statement refers to the QUAL2K model, EPA notes that it is a one dimensional model used to set water quality based effluent limitation and considers an average flow.” (Defendant’s Statement of Facts Genuinely in Issue, p.14)

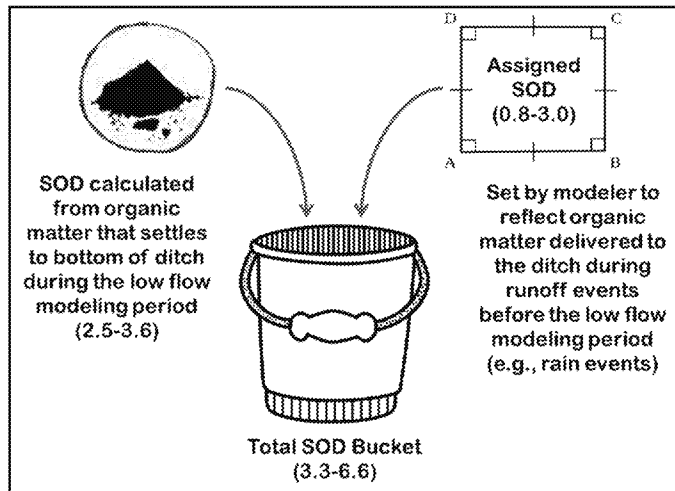
However, as documented in Section III, the QUAL2K model was in fact critical to establishing WLAs during critical low flow conditions. Additionally, the TMDL states that the “load allocations . . . were calculated based on the total of all headwater and lateral inflows used in the QUAL2K model for the allocation scenario model run” (Administrative Record at 0000034). But this cannot be the case as “[t]he load allocation assigned to nonpoint sources in low flow conditions was zero pounds per day, based on MDNR’s best estimate that during critical low flow conditions there is ‘effectively no flow from nonpoint sources’” (USEPA Statement of Facts, p.7). Regardless, a consistent set of critical flow conditions should have been applied to both the LDCs and the QUAL2K model.

If the appropriate critical low flow condition is in fact zero, then WLAs established to attain Missouri’s dissolved oxygen standard using the QUAL2K model were not established under critical low flow conditions. Had the QUAL2K model assumed zero nonpoint source flow, then it would not have resulted in attainment of Missouri’s dissolved oxygen standard (see Attachment A). In fact under this loading scenario, the QUAL2K model predicts a dissolved oxygen concentration of approximately 3.1 mg/L, which is only 60% of Missouri’s dissolved oxygen standard of 5 mg/L. If, on the other hand, the QUAL2K model correctly accounted for critical low flow values, then reasonable assurances are required for necessary loading reductions during critical conditions (see Section VI). Either way, the TMDL fails to demonstrate compliance with the dissolved oxygen standard.

## **V. Sediment Oxygen Demand and the Role of Nonpoint Sources**

Sediment oxygen demand (SOD) can be a significant fraction of the total oxygen demand, particularly in small streams during low flow conditions (Administrative Record at 0001838). As discussed in the City’s Expert Report (pp.12-13) and the Declaration of Dr. Steven Wang (pp.18-20, pp.25-27), the SOD in the QUAL2K model is comprised of two components: SOD

calculated by the model as a result of organic matter settling to the bottom of the ditch and subsequently decaying (calculated SOD); and SOD that is prescribed or assigned by the modeler (assigned SOD). The graphic to the right is a conceptual diagram of how SOD is represented in the QUAL2K model.



As organic matter delivered to the ditch from nonpoint and point sources is reduced to reflect the TMDL loadings, the calculated SOD is reduced by the QUAL2K model. But the assigned SOD also needs to be reduced to reflect the nonpoint and point source load

reductions in the TMDL that enter the ditch prior to the low flow modeling period (e.g., during spring rainfall/runoff events). To account for this, USEPA reduced the assigned SOD of 0.8-3.0 grams of oxygen per square meter per day ( $\text{gO}_2/\text{m}^2/\text{day}$ ) to 0.05  $\text{gO}_2/\text{m}^2/\text{day}$  in the QUAL2K model critical condition scenario. This represents a 93% to 98% reduction in assigned SOD.

It is worth noting again that no SOD data are available for which to verify either the calculated or assigned SOD. As this is such an important model parameter controlling calculated dissolved oxygen levels, the SOD should be measured in Buffalo Ditch to either confirm or refute the values used in the QUAL2K model. Instead of directly measuring SOD, EPA relied on SOD literature values (p.187) from the 1985 USEPA Guidance Document *Rates, Constants, and Kinetic Formulations in Surface Water Quality Modeling* (Administrative Record at 0001307-0001778) that indicate the QUAL2K model SOD values “were in the range (2-10  $\text{gO}_2/\text{m}^2/\text{day}$ ) suggested by [the] US EPA 1985 report” (Declaration of Dr. Steven Wang, p.19). It should be noted that this SOD range was for a sediment type described as “municipal sewage sludge – outfall vicinity”, which implies relatively untreated municipal wastewater. Regardless, the importance of this model input on accurately calculating dissolved oxygen concentrations in Buffalo Ditch justifies that actual data be obtained to support the SOD values used in the QUAL2K model.

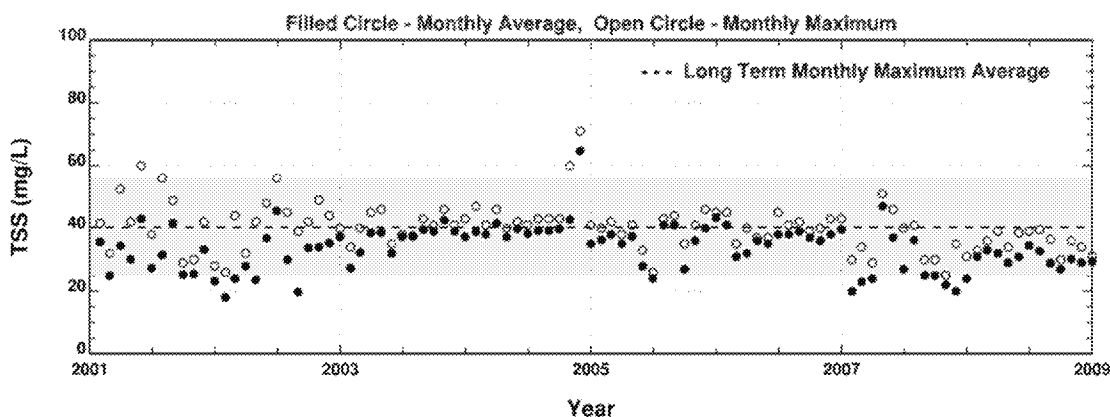
Although a reduction in the assigned SOD is required to account for the nonpoint and point source load reductions, USEPA did not provide a quantitative link between the point and nonpoint source load reductions and the reduction to the assigned SOD. In the Declaration of Dr. Steven Wang (p.26), the justification for reducing the assigned SOD is that the lower assigned SOD values are “representative of the ecoregional reference conditions as the ecoregional nutrient criteria were used for both the nonpoint and point sources.” However, no known datasets are available to estimate ecoregional SOD reference conditions or the linkage between ecoregional nutrient criteria and SOD levels.

The “representative” method USEPA used to reduce the assigned SOD basically assumes that 97% of the organic matter delivered to the ditch during prior nonpoint runoff events is also reduced. However, no justification for how the nonpoint and point source load reductions equate to the assigned SOD reduction is provided.

USEPA asserts that the assigned SOD accounts for both episodic discharges from the Kennett WWTP and nonpoint source runoff:

“a prescribed SOD was used to account for the organics associated with episodic discharges of organic solids from the Kennett WWTP (e.g., solids released during uncontrolled discharge events and other periods of inadequate treatment) and any runoff from the nonpoint source.” (Declaration of Dr. Steven Wang, p.18)

Therefore, the Kennett WWTP discharge monitoring report (DMR) effluent data from the record (Administrative Record at 0004089-0004090) were reviewed to determine if episodic discharges could account for the assigned SOD in the QUAL2K model. The DMR effluent data for total suspended solids (TSS) from 2001-2008 are presented in Figure 3 below as a function of time and present the long term average of the monthly maximum TSS data as the dashed line with the shaded region representing  $\pm 2$  standard deviations around the long term average. The TSS measurement reflects both organic and inorganic solids so it is a good measure to use for assessing if episodic discharges occurred at the Kennett WWTP. These effluent data show that for the last 8 years of data in the administrative record there have only been a few episodic discharge events from the Kennett WWTP and over the last 4 years there have not been any episodic discharge events. For this assessment, an episodic discharge event was defined as a TSS effluent value greater than 2 standard deviations above the long term average. Therefore, the potential for episodic discharges from the Kennett WWTP to contribute to SOD in the ditch is considered negligible and nonpoint sources from prior runoff events must be the major contributor to the assigned SOD.



**Figure 3.** Kennett WWTP DMR Effluent Data (2001-2008) (Administrative Record at 0004089-0004090)

We do not dispute the fact that SOD is an important factor affecting dissolved oxygen concentrations in Buffalo Ditch, as was described in the Declaration of Dr. Steven Wang. However, we do question how the assigned SOD was used to show compliance with the MDNR dissolved oxygen standard. That is, the reduction to the assigned SOD (i.e., 93% to 98% reduction both upstream and downstream of the Kennett WWTP) in the QUAL2K model critical condition scenario at the TMDL load allocations used to show compliance with the MDNR dissolved oxygen standard is not supported. To provide this justification, a quantitative linkage is needed between the nonpoint and point source reductions necessary to achieve the reduced assigned SOD and show compliance with the MDNR dissolved oxygen standard.

In addition, the QUAL2K model critical condition scenario at the TMDL load allocations used to show compliance with the MDNR dissolved oxygen standard includes two forms of nonpoint source reductions: (1) reduced nonpoint source loads during the low flow modeling period and (2) reduced nonpoint source loads during runoff events prior to the low flow modeling period that reflect reduction of the assigned SOD.

## **VI. Nonpoint Source Reductions and Reasonable Assurances**

The City's Expert Report documented that the QUAL2K model used to develop the TMDL included significant reductions in nonpoint source pollutant loadings during critical low flow conditions (Expert Report, pp.13-14). Furthermore, the Expert Report asserts that the TMDL lacks reasonable assurances that such reductions in nonpoint source loadings will occur (Expert Report, p.15). USEPA does not dispute that the QUAL2K model included reductions in nonpoint source loadings. However, USEPA does dispute loading calculations presented within the Expert Report and they dispute the relevance of the QUAL2K model with respect to reasonable assurances.

USEPA's criticism of load reductions calculated in the Expert Report is based on questionable assumptions, but more importantly it is irrelevant with respect to the overarching point that the QUAL2K model required significant nonpoint source reductions to show compliance with Missouri's dissolved oxygen standards. This is apparent on closer analysis of USEPA's assertions shown below:

“The TMDL and load reduction calculated by the City of Kennett is not correct (Tables 2 and 3, Plaintiff's *Explanation of the Buffalo Ditch TMDL*). First, Reach 5 (most downstream reach in the Q2 model, see Figure 7) is not impaired according to the MDNR assessment yet it is included in the City's calculation, which significantly overestimated the nonpoint source loads while minimizing the load contribution from the Kennett WWTP on the 3-mile impaired stream section. EPA Ex. 1 at ii. Second, the City's TSS load calculation is different from the Q2K modeling results. Third, . . . [t]he TMDL document clearly demonstrates that the nutrient and TSS loads for the Buffalo Ditch were

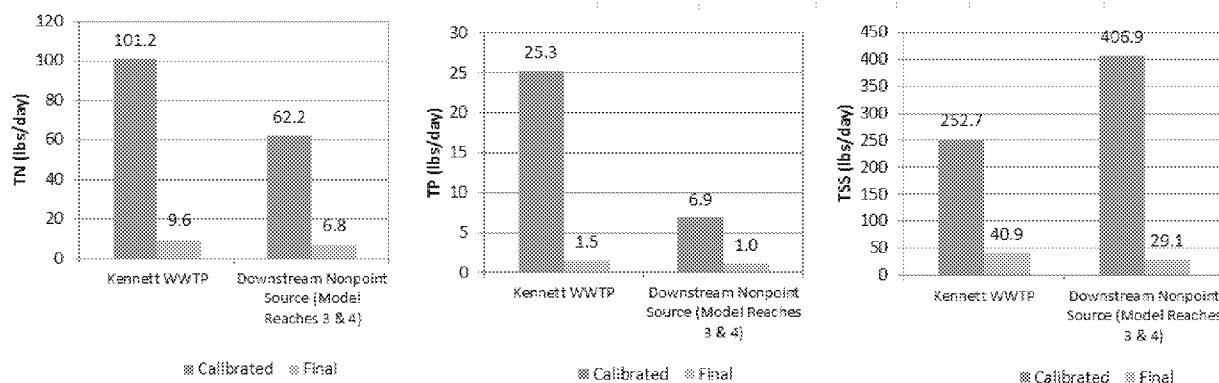
calculated by the LDCs and the recommended ecoregional criteria.” (Declaration of Dr. Steven Wang, p.24)

With respect to USEPA’s first point, Buffalo Ditch is impaired downstream in the three-mile section (see Section II) and the TMDL clearly intended to address all loadings accounted for in the QUAL2K model as evident below:

“The load allocations in Tables 7 through 9 were calculated based on the total of *all* headwater and lateral inflow loads used in the QUAL2K model for the allocation scenario model run. The load allocations are intended to allow the dissolved oxygen target to be met at *all* locations within the stream (emphasis added).” (Administrative Record at 0000034)

With respect to USEPA’s second point, this apparent discrepancy is due to differences in how TSS is calculated. While we contend that the Expert Report correctly calculated TSS and there is no discrepancy, this does not alter the fact that the QUAL2K model included significant nonpoint source reductions. With respect to USEPA’s third point, calculations of nutrient and TSS loads linked to attainment of Missouri’s dissolved oxygen standard can only be obtained from the QUAL2K model (see Section III).

To illustrate the point that USEPA’s criticisms, while unfounded, do not alter the overarching point that the QUAL2K model incorporated significant nonpoint source reductions, revised loadings are presented below in Figure 4. Nonpoint source pollutant loadings presented in Figure 4 are limited to model reach segments within the “3-mile impaired stream section”. Additionally, the TSS calculations in Figure 4 conservatively reflect the TSS calculation presented in Table 7 of the Declaration of Dr. Steven Wang (p.24). Figure 4 demonstrates that there are still significant nonpoint source loading reductions between the calibrated (i.e., existing conditions) and final (i.e., compliance scenario) QUAL2K model runs.



**Figure 4.** Pollutant Loads Assigned in the QUAL2K TMDL Model for Calibration and TMDL Compliance (Administrative Record at 0005057 and 0005061)

Having established that the QUAL2K model included significant reductions in nonpoint sources, the TMDL is required to include reasonable assurances that such reductions will occur. However, USEPA disputes that reasonable assurances are required on the basis that there is no load allocation assigned to nonpoint sources during critical low flow conditions:

- ∞ “The State set the nonpoint source LA during critical low flow at zero pounds per day. This zero nonpoint source contribution and zero load allocation under critical low flow conditions requires no further reasonable assurance analysis because there is essentially no reduction required of the nonpoint sources” (Declaration of Tabatha Adkins, p.12).
- ∞ “Reasonable assurance is provided in TMDLs where the waterbody is impaired by both point and nonpoint sources, and where the wasteload allocation is based on the assumption that nonpoint source load reductions will occur. The TMDL does not call for load reductions from nonpoint sources in critical low flow.” (USEPA’s Statement of Facts, p.9)

USEPA’s assertion that there is no nonpoint source load allocation is based on the LDC, which was not used to set wasteload allocations and does not demonstrate compliance with dissolved oxygen water quality standards (see Section III). Furthermore, the TMDL includes the inaccurate assumption that loadings in the LDC load allocations reflect loadings in the QUAL2K model. As noted in the TMDL:

“The load allocations in Tables 7 through 9 were calculated based on the total of all headwater and lateral inflow loads used in the QUAL2K model for the allocation scenario model run.” (Administrative Record at 0000034)

As documented in the Expert Report and in Figure 4 above, the QUAL2K model does in fact include nonpoint source loadings. Therefore, USEPA’s assertion that reasonable assurances are not required during critical low flow conditions is unfounded. In addition, the TMDL includes larger nonpoint source reductions during higher flow conditions as these loadings influence SOD impacts during critical low flow conditions. Therefore, reasonable assurances are needed during the entire range of flows and nonpoint source loadings.

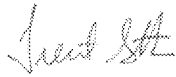
## **VIII. Summary**

The Buffalo Ditch TMDL administrative record and USEPA’s response documents demonstrate that the TMDL was not adequately established to implement Missouri’s dissolved oxygen standard assigned to Buffalo Ditch. Specifically, the TMDL does not provide adequate reasonable assurances that reductions in nonpoint source loadings and sediment oxygen demand, which were determined to be necessary for achieving the Missouri dissolved oxygen standards, will be achieved during critical low flow conditions. Additionally, the TMDL water quality model used to demonstrate compliance with water quality standards did not incorporate critical low flow conditions as defined by the TMDL (i.e., zero nonpoint source flow). These findings are supported by the explanations provided in this report and are summarized below:

Supplemental Explanations of the Buffalo Ditch TMDL in *City of Kennett, Missouri v. United States Environmental Protection Agency*, Case No. 1:14-cv-00033-SNLJ. Page 17



1. Missouri's dissolved oxygen standard of 5 mg/L is not typically attained within the Buffalo Ditch region (e.g., upstream of Kennett WWTP and at nearby reference stations). This indicates that regional conditions outside the influence of the City significantly contribute to lack of dissolved oxygen attainment.
2. Despite USEPA assertions to the contrary, the QUAL2K model, and not the LDC approach, was used to derive wasteload allocations and demonstrate compliance with Missouri's dissolved oxygen standard. However, the load allocations assigned in the TMDL for critical low flow conditions are based on the LDC approach, which does not provide a quantitative link between nutrient loads and dissolved oxygen.
3. Critical low flow conditions as defined in the TMDL (i.e., zero nonpoint source flow) were applied to the nonpoint source load allocations but not the QUAL2K water quality model. The QUAL2K water quality model, which was used to derive wasteload allocations and demonstrate compliance with Missouri's dissolved oxygen standard, assumed nonpoint source flows ranging from 1.3 to 4.7 cfs. Additionally, USEPA experts disagree on the appropriate 7Q10 critical low flow value for Buffalo Ditch.
4. The QUAL2K model used to establish the wasteload allocation assumed an arbitrary 93% to 98% reduction in assigned SOD. A significant fraction of the assigned SOD in the QUAL2K model downstream from the Kennett WWTP is due to nonpoint sources contributing organic matter during prior rainfall/runoff events. The TMDL provides no reasonable assurances that the reduction in assigned SOD will occur.
5. The QUAL2K model used to establish wasteload allocations demonstrates that significant reductions in nonpoint sources of TP, TN, and TSS are required to achieve Missouri's dissolved oxygen standard of 5 mg/L. However, the TMDL provides no reasonable assurances that this reduction in nonpoint sources will occur during critical low flow conditions.



John Stober, PE  
HDR



Andrew Thuman, PE  
HDR

ATTACHMENT A

ILLUSTRATIVE QUAL2K MODEL SCENARIOS

As discussed within this report, the only quantitative or analytical tool available as part of the TMDL record to determine “the relationship between the source loadings of biochemical oxygen demand and nutrients on dissolved oxygen is generated by the water quality model QUAL2K” (Administrative Record at 0000033). Therefore, the QUAL2K model is the only tool for demonstrating attainment of Missouri’s dissolved oxygen standard as a result of the TMDL load allocations. As the only tool used to show standards attainment, the QUAL2K model is also useful for illustrating the effect of contradictory critical conditions presented in the administrative record and for showing the effect of different wasteload allocations (WLA) on dissolved oxygen levels in Buffalo Ditch. To this end, model sensitivities were completed using the QUAL2K model in the record to calculate dissolved oxygen concentrations for the following scenarios (Administrative Record at 0005057).

1. Critical nonpoint source “zero” low flow conditions with the Kennett WWTP at the TMDL WLA (100% flow exceedance from Tables 7-9 of the TMDL). This scenario represents the critical condition defined in one instance in the TMDL report when using the LDC approach for calculating nonpoint source load reductions over a range of ditch flows.
2. QUAL2K critical low flow condition with nonpoint source TMDL allocations (“non-zero”) along with the Kennett WWTP at higher effluent nutrient levels. The Kennett WWTP effluent concentrations were assigned at a TN of 10 mg/L, TP of 1 mg/L, TSS of 5 mg/L and BOD of 5 mg/L. These effluent nutrient concentrations are significantly greater than the TMDL WLA but represent technologically achievable levels with biological nutrient removal. This non-zero nonpoint source critical condition equates to a flow exceedance of approximately 70% based on the LDCs. This model run represents the QUAL2K critical condition assumption with significantly greater nutrient wasteload allocations.

Table 1 presents the calculated minimum dissolved oxygen concentrations downstream of the Kennett WWTP for the model scenarios along with the existing condition (TMDL Calibration) and TMDL allocation scenario (TMDL Case D) model runs for reference (Administrative Record at 0005061 and 0005057).

The QUAL2K model Scenario 1 results show that the 100% flow exceedance (TMDL Tables 7-9) critical condition (zero nonpoint source load) as defined in the TMDL does not result in dissolved oxygen standard attainment. The QUAL2K model calculated minimum dissolved oxygen concentration downstream from the KWTP is 3.08 mg/L. Therefore, the TMDL critical condition with just the Kennett WWTP WLA will not attain Missouri’s dissolved oxygen standard.

The QUAL2K model Scenario 2 results show that there is a relatively small difference (less than 0.3 mg/L) in the QUAL2K model calculated dissolved oxygen concentrations between the Kennett WWTP at the WLA and at significantly higher effluent nutrient levels. It should be

noted that this model scenario includes nonpoint source flow (non-zero) and also the assigned nonpoint source load reductions to the ecoregional nutrient reference values. Therefore, requiring the effluent limits equal to the ecoregional nutrient reference values, and at an unattainable TN effluent limit (0.76 mg/L), is not only unrealistic but only impacts dissolved oxygen levels by less than 0.3 mg/L.

<b>Table 1. QUAL2K Model Scenario Results</b>	
<b>Scenario</b>	<b>Minimum DO Downstream from Kennett WWTP (mg/L)</b>
Existing Condition (Model Calibration) See TMDL Figure C-5, Calibration	2.02
TMDL Allocation Scenario See TMDL Figure C-5, Case D	4.97
100% Flow Exceedance & Kennett WWTP WLA (Scenario 1)	3.08
TMDL Allocation Scenario with higher Kennett WWTP (Scenario 2)	4.74

The TMDL report (pp. 24-25) states that “due to issues regarding low dissolved oxygen as a natural background condition, the department may develop revised dissolved oxygen criteria for Buffalo Ditch and similar streams during the next Triennial Review of the Water Quality Standards.” Since EPA and MDNR acknowledge the issues with low dissolved oxygen in the TMDL report, it seems prudent to acknowledge the uncertainty in the TMDL load reduction estimates needed to attain Missouri’s dissolved oxygen standard and pursue the development of revised dissolved oxygen criteria for Buffalo Ditch, while still requiring some level of Kennett WWTP upgrades as part of improving downstream dissolved oxygen levels.

Explanations of the Buffalo Ditch TMDL by John Stober and Andrew Thuman regarding

*City of Kennett, Missouri v. United States Environmental Protection Agency*

Case No.: 1:14-cv-00033-SNLJ

January 14, 2016

## I. Introduction

Under the Clean Water Act states and authorized tribes are required to develop Total Maximum Daily Loads (“TMDL”) for waters that do not meet water quality standards (“WQS”) as listed on the State’s 303(d) impaired waters list. Water quality standards establish the goals for a specific water body by designating the use or uses to be made of the water as well as the criteria necessary to protect those uses. A TMDL is a calculation of the maximum amount of a pollutant that a water body can receive and still attain water quality standards.<sup>1</sup>

A TMDL takes into account point sources of pollution (e.g., wastewater treatment facilities) as represented by a wasteload allocation (“WLA”), nonpoint sources (e.g., agriculture and natural background) as represented by a load allocation (“LA”), and a margin of safety (“MOS”).<sup>2</sup> Point source pollutants include effluent discharges from municipal and industrial wastewater treatment plants. Nonpoint source loading of pollutants results from the transport of pollutants into receiving waters via overland surface runoff (e.g., agricultural land runoff) and groundwater discharge within a drainage basin.<sup>3</sup> The margin of safety accounts for uncertainties in scientific and technical understanding of the linkage between pollutant loads and water quality (e.g., dissolved oxygen).<sup>4</sup> The TMDL equation is expressed as:

$$\text{TMDL} = \Sigma \text{WLA} + \Sigma \text{LA} + \text{MOS}$$

Per 40 CFR § 130.7(c)(1), determinations of TMDLs shall take into account critical conditions for stream flow, loading, and water quality parameters. Critical conditions are factors such as flow or temperature which may lead to excursions of water quality standards.<sup>5</sup> Such conditions typically occur during the summer when flow is low and temperature is high.<sup>6</sup> TMDL’s must also provide reasonable assurances that nonpoint source control measures will achieve expected load reductions, where the wasteload allocation is based on an assumption that nonpoint source load reductions will occur.<sup>7</sup>

An essential component of developing a TMDL is establishing a relationship between the source loadings and the resulting water quality.<sup>8</sup> In order to provide this linkage, water quality models are routinely used in developing TMDLs and are critical for demonstrating that TMDLs are adequately established to implement the water quality standards as required by 33 U.S.C. §1313(d)(1)(C). A water quality model is a mathematical tool for simulating the movement of water through a water body (e.g., flow, velocity, depth) and the important water quality

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<sup>1</sup> See Administrative Record at 0000015.

<sup>2</sup> See Administrative Record at 0000033.

<sup>3</sup> See Administrative Record at 0001828.

<sup>4</sup> See Administrative Record at 0000023.

<sup>5</sup> See Administrative Record at 0000008.

<sup>6</sup> See Administrative Record at 0005632.

<sup>7</sup> See Administrative Record at 0005650.

<sup>8</sup> See Administrative Record at 0000033.

processes that affect various parameters (e.g., dissolved oxygen, nutrients, algae (aquatic plants), and biochemical oxygen demand).<sup>9</sup>

This report provides a review of the United States Environmental Protection Agency (“USEPA”) approved TMDL for Buffalo Ditch and its supporting water quality model, which was used for setting wasteload allocations for the Kennett Wastewater Treatment Plant (“WWTP”).

## **A. Setting**

Buffalo Ditch originates on the northeast side of Kennett, Missouri and flows south-southwest into the state of Arkansas (Figure 1).<sup>10</sup> It is located in the low-lying “Bootheel” region of southeastern Missouri and is part of the Little River Drainage District, which was formed in 1907 with the goal of opening the region for settlement and agricultural production.<sup>11</sup> In the early 20<sup>th</sup> century, the Little River Drainage District administered the construction of a system of ditches, levees and canals throughout the “Bootheel” region.<sup>12</sup> These man-made drainage ditches and canals converted wetlands that previously dominated the region into “exceedingly-rich” cropland that today supports soybean, corn, grain sorghum, cotton, and rice farming.<sup>13</sup> Prior to draining the land, less than 10% of the region was clear of water.<sup>14</sup> Today the Buffalo Ditch watershed consists of 91% cropland.<sup>15</sup>

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<sup>9</sup> See Administrative Record at 0001307-0001778.

<sup>10</sup> See Administrative Record at 0000015.

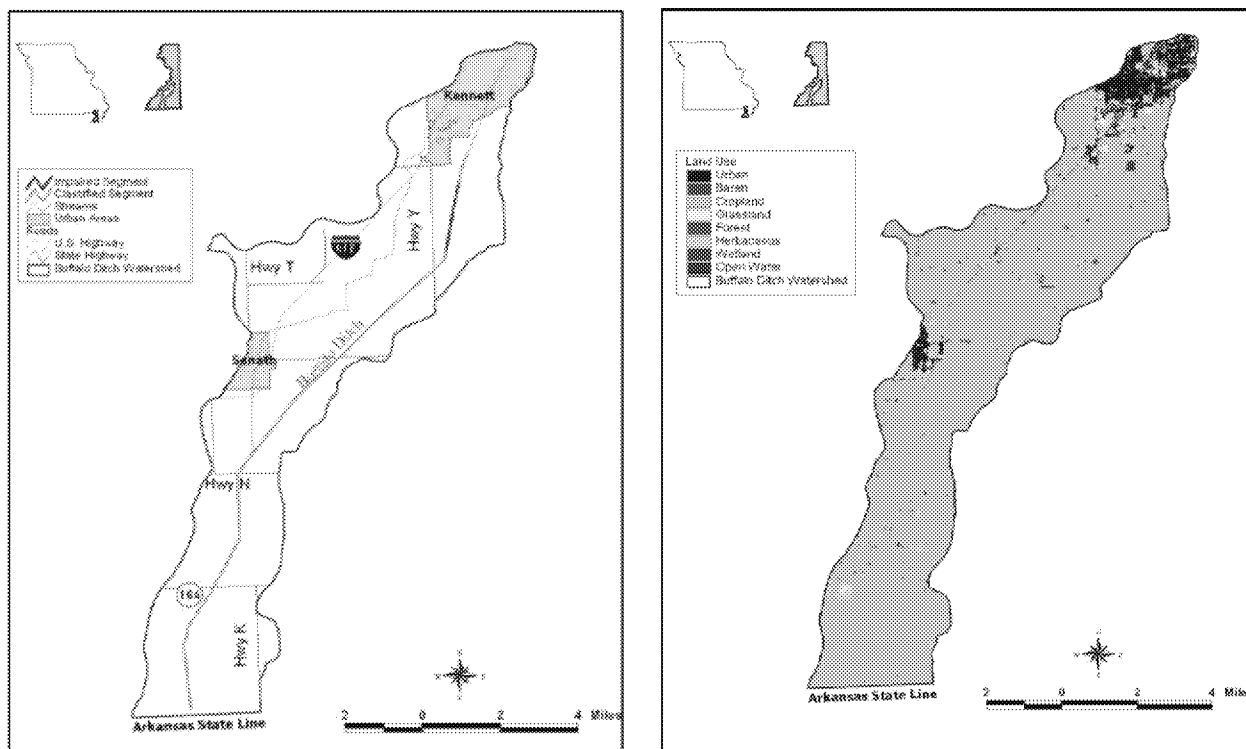
<sup>11</sup> See Administrative Record at 0000017.

<sup>12</sup> See Administrative Record at 0004219-0004220.

<sup>13</sup> See Administrative Record at 0004222.

<sup>14</sup> See Administrative Record at 0004219.

<sup>15</sup> See Administrative Record at 0000018-0000019.



**Figure 1.** Location of Buffalo Ditch (TMDL Figures 1 and 2)<sup>16</sup>

## **B. Impairment History**

Buffalo Ditch was initially included on the Missouri Department of Natural Resources' (MDNR) 1994 Section 303(d) List of impaired waters for biochemical oxygen demand.<sup>17</sup> Biochemical oxygen demand refers to the amount of oxygen consumed by microorganisms in breaking down organic matter and is considered a surrogate for the degree of oxygen consuming organic matter in water.<sup>18</sup> There are no water quality standards for biochemical oxygen demand, but it is frequently linked to dissolved oxygen which has a minimum allowable standard of 5 milligrams per liter (mg/L) in the State of Missouri.<sup>19</sup> To provide a more understandable 303(d) list to the general public, MDNR changed the name of the pollutant causing the impairment from biochemical oxygen demand to dissolved oxygen on the 2004/2006 303(d) List.<sup>20</sup>

## **C. Importance of Dissolved Oxygen to Aquatic Life**

Dissolved oxygen (i.e., the oxygen present in water) is an indicator of overall stream health as it is vital for the survival of aquatic organisms.<sup>21</sup> Low dissolved oxygen levels can be a sign of pollutants tied to oxygen consumption such as organic matter and may be due to a variety of

<sup>16</sup> See Administrative Record at 0000016 and 0000019.

<sup>17</sup> See Administrative Record at 0000017.

<sup>18</sup> *Id.*

<sup>19</sup> See Administrative Record at 0001210.

<sup>20</sup> See Administrative Record at 0000017.

<sup>21</sup> See Administrative Record at 0002351.



physical factors such as temperature, flow, and stream gradient.<sup>22</sup> The amount of oxygen needed varies between organisms with the more sensitive populations (e.g., smallmouth bass, walleye and early life stages of fish) typically requiring higher levels of oxygen, whereas less sensitive populations (e.g., largemouth bass, black crappie, white sucker, and white bass) can survive with less.<sup>23</sup> As oxygen levels are depleted, more sensitive aquatic insects (e.g., early life stages of mayflies and stoneflies) will also be replaced by more pollutant-tolerant organisms (e.g., aquatic worms and early life stages of midges).

#### **D. Factors Controlling Dissolved Oxygen Levels**

Dissolved oxygen levels are determined by a balance of oxygen-depleting processes (e.g., decomposition of organic matter) and oxygen-restoring processes (e.g., atmospheric reaeration or replenishment).<sup>24</sup> Typically in streams, the most significant processes include photosynthesis and respiration of algae, atmospheric reaeration, nitrification of ammonia, and oxidation of biochemical, and sediment oxygen demand (Figure 2). Nitrogen and phosphorus can contribute to low dissolved oxygen problems because these plant nutrients can accelerate algae growth in streams.<sup>25</sup> The algae consume dissolved oxygen during respiration at night when oxygen production from photosynthesis is not occurring and have the potential to remove large amounts of dissolved oxygen from the stream.<sup>26</sup> The effects of sediment oxygen demand can be a significant fraction of total oxygen demand, particularly in smaller streams where large amounts of organic matter in the sediment are present. The decomposition of organic matter and respiration of resident invertebrates form the major oxygen demands from the sediment.<sup>27</sup>

The influence of oxygen-depleting and oxygen-restoring processes on dissolved oxygen levels varies between streams and are constrained by additional factors including season, temperature and flow, physical characteristics (e.g., gradient, catchment geology), organic enrichment, algal productivity, and decomposition.<sup>28</sup> During critical summertime conditions, higher temperatures and lower stream flows significantly influence dissolved oxygen levels. Warmer water lowers the dissolved oxygen saturation capacity of streams and accelerates chemical and biological oxygen-consuming processes. As oxygen-depleting processes increase during summertime conditions, lower stream flows result in less atmospheric reaeration. Physical factors such as a low stream gradient also contribute to slower stream velocity and less atmospheric reaeration.<sup>29</sup>

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<sup>22</sup> See Administrative Record at 0002187-0002198.

<sup>23</sup> *Id.*

<sup>24</sup> See Administrative Record at 0001236-0001260 and 0001307-0001778.

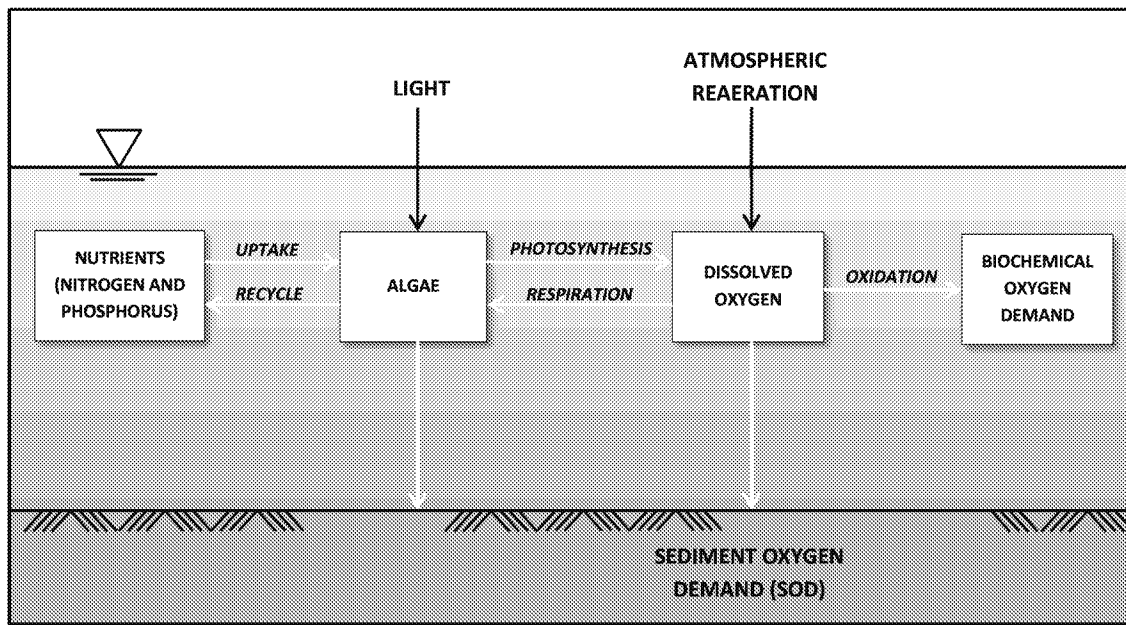
<sup>25</sup> See Administrative Record at 0000026.

<sup>26</sup> See Administrative Record at 0000027.

<sup>27</sup> See Administrative Record at 0001838.

<sup>28</sup> See Administrative Record at 0002193-0002196.

<sup>29</sup> *Id.*



**Figure 2.** Dissolved Oxygen Balance<sup>30</sup>

### E. Buffalo Ditch TMDL Water Quality Model

For the Buffalo Ditch TMDL, the relationship between the source loading of biochemical oxygen demand and nutrients on dissolved oxygen was calculated by a water quality model, which is an integral part of the TMDL process.<sup>31</sup> A water quality model is a mathematical tool for simulating the movement of water through a water body (e.g., flow, velocity, depth) and the important water quality processes that affect various parameters (e.g., dissolved oxygen, nutrients, algae (aquatic plants) and biochemical oxygen demand).<sup>32</sup> The model also accounts for the point and nonpoint source pollutant loads that affect water quality.<sup>33</sup>

The water quality model developed and applied to the Buffalo Ditch TMDL is the USEPA supported QUAL2K model.<sup>34</sup> QUAL2K is a one-dimensional model (well-mixed water body both vertically and laterally) that simulates basic stream water movement and water quality processes.<sup>35</sup> Processes simulated in the TMDL water quality model address nutrient cycles, algal growth (photosynthesis and respiration), dissolved oxygen dynamics, such as, biochemical oxygen demand oxidation, sediment oxygen demand, and atmospheric reaeration.<sup>36</sup> Sediment oxygen demand is the oxygen consumption due to decaying organic matter in the sediments of a

<sup>30</sup> Figure adapted from the Administrative Record at 0001237-0001238 and 0001840.

<sup>31</sup> See Administrative Record at 0000033 and 0001903.

<sup>32</sup> See Administrative Record at 0001307-0001778.

<sup>33</sup> See Administrative Record at 0001115, 0001220-0001221, and 0001279-0001280.

<sup>34</sup> See Administrative Record at 0000033.

<sup>35</sup> See Administrative Record at 0001218.

<sup>36</sup> *Id.*

water body.<sup>37</sup> Atmospheric reaeration represents the transfer (addition) of oxygen to the water body from the atmosphere.<sup>38</sup> The basic water quality processes included in the TMDL model are presented above in Figure 2.

The process of developing a TMDL model, such as the Buffalo Ditch model, is to: 1) define the stream geometry based on measurements; 2) assign flow and water quality inputs from upstream, point and nonpoint sources; and 3) complete model calibration and validation analyses.<sup>39</sup> Model calibration refers to the process of adjusting various model parameters (e.g., biochemical oxygen demand oxidation rate, sediment oxygen demand) to within acceptable ranges as defined by literature and standard modeling practice so model calculations acceptably match field data.<sup>40</sup> Model validation is an extension of the calibration process and refers to testing the calibrated model against a separate, independent dataset using the same model calibration parameters.<sup>41</sup> Once an acceptable level of model calibration and validation is achieved, the model is considered useful for projecting water quality changes associated with management actions (e.g., reduced point and nonpoint source loads).<sup>42</sup> In this projection mode, a water quality model becomes a critical component of TMDLs that are focused on defining the load capacity of a water body so that water quality standards are attained. The calibrated and validated water quality model becomes the linkage between the parameter of concern (i.e., dissolved oxygen) and regulated pollutants (i.e., nutrients and biochemical oxygen demand).<sup>43</sup>

The Buffalo Ditch TMDL model was calibrated to continuous dissolved oxygen data and discrete nutrient, biochemical oxygen demand and algae data collected during the May 21, 2008 low-flow sampling event.<sup>44</sup> The model was setup for an approximately 6 mile reach of Buffalo Ditch (about 2 miles upstream and 4 miles downstream from the Kennett WWTP).<sup>45</sup> The model output reasonably reproduced the observed data and included nutrient and biochemical oxygen demand loads from upstream, the Kennett WWTP, and nonpoint source inputs along the length of the ditch.<sup>46</sup> USEPA collected validation data during the September 5, 2008 low-flow sampling event and attempted to provide a model validation within an earlier draft TMDL document version dated April 10, 2009.<sup>47</sup> However, peer review comments questioned the model validation, in particular the assignment of very different sediment oxygen demand rates

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<sup>37</sup> See Administrative Record at 0001258-0001260 and 0001496-0001511.

<sup>38</sup> See Administrative Record at 0001249-0001251 and 0001425-0001458.

<sup>39</sup> See Administrative Record at 0001877-0001903.

<sup>40</sup> See Administrative Record at 0004993.

<sup>41</sup> See Administrative Record at 0004994.

<sup>42</sup> See Administrative Record at 0004769.

<sup>43</sup> See Administrative Record at 0000033.

<sup>44</sup> See Administrative Record at 0000065.

<sup>45</sup> See Administrative Record at 0000070.

<sup>46</sup> See Administrative Record at 0000066-0000069 and 0005061.

<sup>47</sup> See Administrative Record at 0004756-0004772.

for the model calibration and the model validation.<sup>48</sup> Ultimately, the model validation was not presented in the final TMDL document nor is it clear if model validation was completed.<sup>49</sup>

## F. Buffalo Ditch TMDL

The Buffalo Ditch TMDL established wasteload allocations for the Kennett WWTP and nonpoint source load allocations to meet water quality standards. The wasteload allocations included pollutant limits for total nitrogen, total phosphorus, total suspended solids, and biochemical oxygen demand (Table 1).

**Table 1.** Wasteload Allocations for Kennett Wastewater Treatment Plant<sup>50</sup>

Pollutant	Concentration Limits	WLA at Design Flow (2.17 cfs)
Total Nitrogen	0.76 mg/L	8.9 lbs/day
Total Phosphorus	0.115 mg/L	1.35 lbs/day
Total Suspended Solids	31 mg/L	362.9 lbs/day
Biochemical Oxygen Demand	5 mg/L	58.5 lbs/day

Rationale for including these pollutants and limits, as described in the TMDL, are as follows:

- ∞ Total Nitrogen and Total Phosphorus – Nutrient limits (total nitrogen and total phosphorus) included within the TMDL are intended to control algal growth, which is attributed to causing low dissolved oxygen.<sup>51</sup> The nutrient limits were derived from the USEPA’s nutrient ecoregion reference concentrations.<sup>52</sup>
- ∞ Total Suspended Solids – Fine particle size of bottom sediment and suspended particles of organic matter contribute to low dissolved oxygen.<sup>53</sup> Since both of these pollutants are derived from similar loading conditions of terrestrial and stream bank erosion, the TMDL includes an allocation for suspended solids. Total suspended solids limits were based on the 25<sup>th</sup> percentile of total suspended sediment measurements in the region in which Buffalo Ditch is located.<sup>54</sup>
- ∞ Biochemical Oxygen Demand – Biochemical oxygen demand is the measure of oxygen used by microorganisms to decompose organic matter.<sup>55</sup> Excessive loads of decaying organic solids, as measured by biochemical oxygen demand may be contributing to low dissolved oxygen in Buffalo Ditch.<sup>56</sup> The wasteload allocation for biochemical oxygen

<sup>48</sup> See Administrative Record at 0004764.

<sup>49</sup> See Administrative Record at 0000065-0000070.

<sup>50</sup> See Administrative Record at 0000037.

<sup>51</sup> See Administrative Record at 0000028.

<sup>52</sup> See Administrative Record at 0000032.

<sup>53</sup> See Administrative Record at 0000031.

<sup>54</sup> See Administrative Record at 0000032.

<sup>55</sup> See Administrative Record at 0000017.

<sup>56</sup> See Administrative Record at 0000020.

demand was derived from the TMDL model that purported to result in meeting water quality standards.<sup>57</sup>

The Buffalo Ditch TMDL also includes an implicit margin of safety based on conservative assumptions applied to the TMDL model.<sup>58</sup> These assumptions reportedly include targeting the 25<sup>th</sup> percentile of total suspended solids concentrations and establishing wasteload allocations for the Kennett WWTP under critical low-flow conditions when discharge from this facility will dominate the stream flow.<sup>59</sup>

## **II. Explanations of the Buffalo Ditch TMDL Administrative Record Produced by USEPA**

### **A. Regional Conditions Contribute to Dissolved Oxygen Levels Below the Water Quality Standard**

The Buffalo Ditch TMDL targets a minimum allowable dissolved oxygen standard of 5 milligrams per liter (mg/L).<sup>60</sup> However, the TMDL acknowledges that low dissolved oxygen levels represent a natural background issue and that a revised TMDL may be necessary.<sup>61</sup> Specifically, the TMDL states, “low dissolved oxygen is an issue in Buffalo Ditch both *upstream* (emphasis added) and downstream of the Kennett Wastewater Treatment Plant” and “due to issues regarding low dissolved oxygen as a natural background condition, the department may develop revised dissolved oxygen criteria for Buffalo Ditch and similar streams during the next Triennial Review for Water Quality Standards”.<sup>62</sup> Existing and background conditions outside the control of the Kennett WWTP that contribute to low dissolved oxygen levels in Buffalo Ditch include:

- ∞ Predominance of cropland – Approximately 91% of the Buffalo Ditch watershed is cropland area.<sup>63</sup> Lands used for agricultural purposes can be a source of nutrients and oxygen-consuming substances.<sup>64</sup> Cropland also leaves the area more susceptible to soil erosion and pollutant-laden runoff.<sup>65</sup>
- ∞ Lack of riparian cover – Nearly 86% of the riparian corridor (area adjacent to ditch) along Buffalo Ditch is classified as cropland.<sup>66</sup> Another 10 percent of the land is classified as urban, which also lacks adequately vegetated riparian corridor.<sup>67</sup> The loss of

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<sup>57</sup> See Administrative Record at 0000037.

<sup>58</sup> *Id.*

<sup>59</sup> *Id.*

<sup>60</sup> See Administrative Record at 0000004.

<sup>61</sup> See Administrative Record at 0000038-0000039.

<sup>62</sup> *Id.*

<sup>63</sup> See Administrative Record at 0000018.

<sup>64</sup> See Administrative Record at 0000023.

<sup>65</sup> See Administrative Record at 0000025.

<sup>66</sup> *Id.*

<sup>67</sup> *Id.*

vegetative riparian cover results in less shading and higher instream temperatures.<sup>68</sup>

Warmer water lowers the dissolved oxygen saturation capacity of streams and accelerates chemical and biological oxygen-consuming processes, resulting in lower dissolved oxygen levels.<sup>69</sup>

- ∞ Flat terrain – Buffalo Ditch is situated in the low-lying “Bootheel” region in a flat alluvial plain.<sup>70</sup> USEPA estimated slopes in Buffalo Ditch range from approximately 0.02% to 0.05%.<sup>71</sup> Low-gradient streams (less than 1% slope) that experience a reduction in average flow velocity may be more susceptible to declining oxygen due to a decrease in oxygen transfer from the atmosphere.<sup>72</sup>

Conditions described above including the lack of riparian cover and slow, stagnant waters are depicted in Figure 3 below.



**Figure 3.** Buffalo Ditch upstream (left photo) and downstream (right photos) of the Kennett WWTP.<sup>73</sup>

<sup>68</sup> *Id.*

<sup>69</sup> See Administrative Record at 0000024-0000025.

<sup>70</sup> See Administrative Record at 0000015.

<sup>71</sup> See Administrative Record at 0005057.

<sup>72</sup> See Administrative Record at 0002188.

<sup>73</sup> Photos in figure obtained during the 2003 TMDL field studies referenced in the Administrative Record at 0000020.

The inability of Buffalo Ditch and other streams in the surrounding region to achieve Missouri's dissolved oxygen water quality standard of 5 mg/L is empirically evident based on data collected by MDNR and USEPA in 2003 and 2008 to support development of the TMDL.<sup>74</sup> As part of MDNR's 2003 data collection effort, dissolved oxygen data were collected from the following three locations outside the influence of the Kennett WWTP (Figure 4):

- ∞ **Site M1** – Buffalo Ditch approximately 0.9 miles upstream from of the Kennett WWTP.<sup>75</sup>
- ∞ **Site M6** – Ditch #36 at the County Road 502 bridge crossing. According to MDNR's 2003 Stream Survey Sampling Report, this site was chosen in order to characterize dissolved oxygen and other parameters in a local ditch that was unaffected by WWTP discharges.<sup>76</sup>
- ∞ **Site M7** – Ragland Slough at the Highway A bridge crossing. According to MDNR's 2003 Stream Survey Sampling Report, this site was chosen in order to characterize dissolved oxygen and other parameters in a local ditch that was unaffected by WWTP discharges.<sup>77</sup>

As part of USEPA's 2008 data collection effort, dissolved oxygen data were collected from the following three locations outside the influence of the Kennett WWTP (Figure 4):

- ∞ **Site BU-1** – Buffalo Ditch 1.9 miles upstream of the Kennett WWTP at Highway 412.<sup>78</sup>
- ∞ **Site BU-2** – Buffalo Ditch 0.8 miles upstream of the Kennett WWTP at County Road 508.<sup>79</sup>
- ∞ **Site BU-RF** – Unnamed tributary to Main Ditch at County Road 231.<sup>80</sup> According to the TMDL Quality Assurance Project Plan (QAPP), the reference stream was chosen based minimal anthropogenic (human) impact.<sup>81</sup> The QAPP also indicated that data from reference streams were to be used for estimating "background" dissolved oxygen conditions.<sup>82</sup>

Dissolved oxygen levels measured at these sites were far below Missouri's water quality standard of 5 mg/L (Figure 5).

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<sup>74</sup> See Administrative Record at 0003940-0003942, 0004084, and 0004086.

<sup>75</sup> See Administrative Record at 0003900.

<sup>76</sup> See Administrative Record at 0003902.

<sup>77</sup> *Id.*

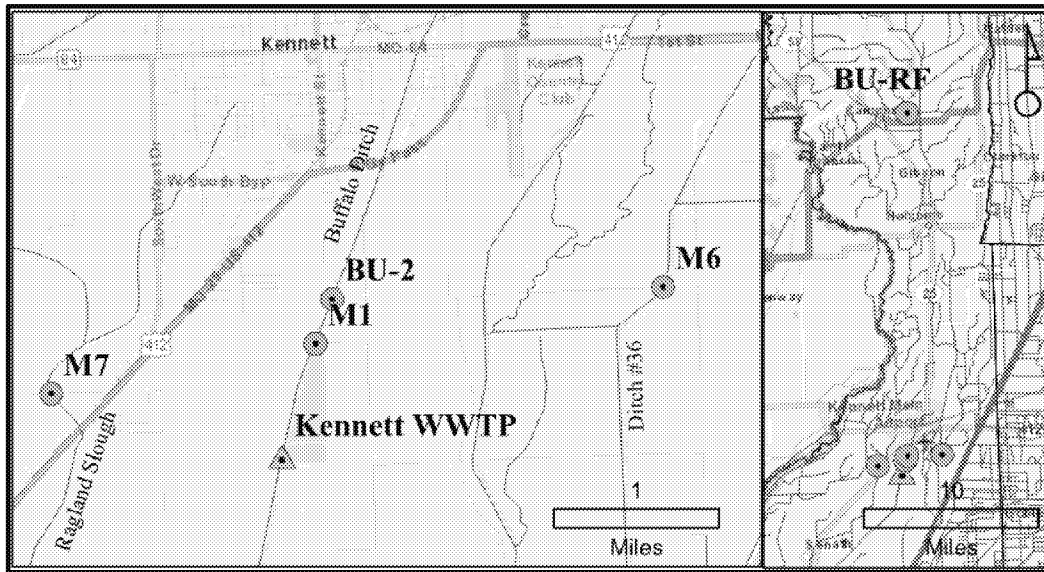
<sup>78</sup> See Administrative Record at 0004853.

<sup>79</sup> *Id.*

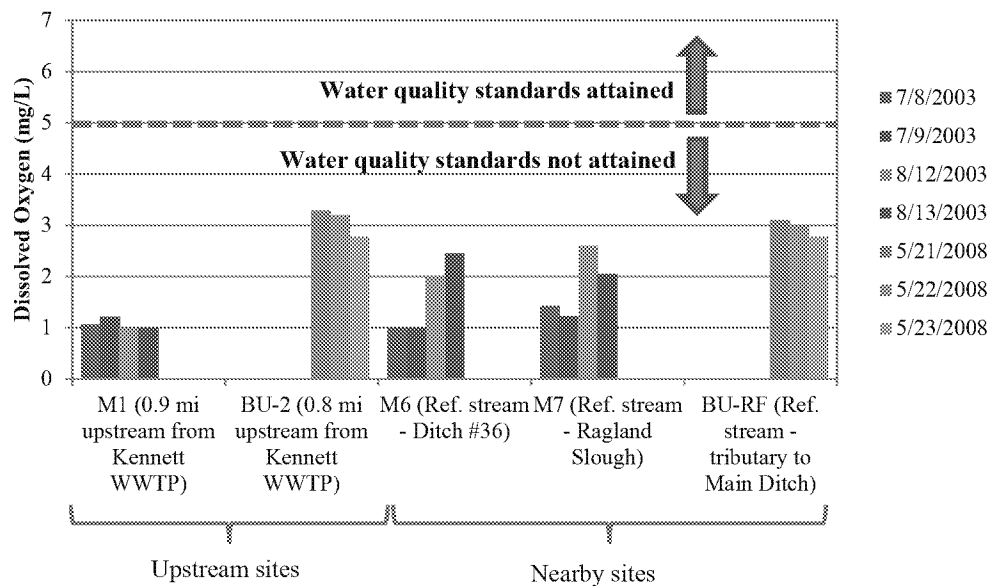
<sup>80</sup> *Id.*

<sup>81</sup> See Administrative Record at 0004819.

<sup>82</sup> See Administrative Record at 0004823.



**Figure 4.** Buffalo Ditch TMDL Upstream and Reference Sites<sup>83</sup>



**Figure 5.** Minimum Dissolved Oxygen Levels Measured at Nearby Ditches and Sites Located Upstream of the Kennett WWTP<sup>84</sup>

<sup>83</sup> Map created from site locations identified in the Administrative Record at 0003900-0003902, 0004853, and 0004874. Dissolved oxygen data from site BU-1 was collected outside of 1 hour of sunrise; therefore is not in conformance with the Quality Assurance Project Plan as described in the Administrative Record at 0004852 and is not included in this figure.



## **B. Large Reductions to Sediment Oxygen Demand are Required to Attain Water Quality Standards**

Sediment oxygen demand can be a significant fraction of the total oxygen demand, particularly in small streams during low-flow and high temperature conditions.<sup>85</sup> In order to calibrate the TMDL model to observed dissolved oxygen data, key sediment oxygen demand assumptions and calculations are required by the modeler. In this case, the assigned sediment oxygen demand varied from 0.8-3.0 gO<sub>2</sub>/m<sup>2</sup>/d, which reflects organic loading to sediment outside of the modeling period (e.g., agricultural source loading), and the total sediment oxygen demand varied from 3.2-6.6 gO<sub>2</sub>/m<sup>2</sup>/d.<sup>86,87</sup> These very high levels of sediment oxygen demand (see Table 3-25 in USEPA's rates and kinetics manual for typical ranges<sup>88</sup>) were needed to reproduce the observed dissolved oxygen data with the model and reflect the high load of organic matter delivered to the ditch. In addition, there are no measurements of sediment oxygen demand in Buffalo Ditch to confirm or refute the sediment oxygen demand values used in the TMDL model.

In order to produce a TMDL model scenario that predicts compliance with the water quality standard during critical conditions (i.e., provide the linkage between dissolved oxygen and regulated parameters), the assigned sediment oxygen demand was reduced from 0.8-3.0 gO<sub>2</sub>/m<sup>2</sup>/d in the calibrated model to 0.05 gO<sub>2</sub>/m<sup>2</sup>/d in the final TMDL model.<sup>89</sup> This reduction in the assigned sediment oxygen demand rate ranged from 93-98%. The TMDL does not address this substantial reduction in sediment oxygen demand nor tie load reductions outside of the modeling period to such a large reduction. Assumptions of sediment oxygen demand reductions were questioned as part of the TMDL review process.<sup>90</sup> In fact, a reviewer of an earlier TMDL draft report that included an initial attempt at model validation made the following comment that highlights the use of the sediment oxygen demand rate in the model as a significant factor in calculating dissolved oxygen levels.

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<sup>84</sup> Figure created from dissolved oxygen data in the Administrative Record at 0003940-0003942, 0004084, and 0004086. Data collected outside of 1 hour of sunrise are not in conformance with the Quality Assurance Project Plan as described in the Administrative Record at 0004852; therefore are not included in this figure.

<sup>85</sup> See Administrative Record at 0001838.

<sup>86</sup> Sediment oxygen demand values assigned in the TMDL model ranged spatially within the Buffalo Ditch model reach. See Administrative Record at 0005061.

<sup>87</sup> The TMDL model includes the ability to calculate sediment oxygen demand accounting for sources discharged to the ditch during and prior to the critical modeling period. Sediment oxygen demand impacts from sources during the critical period are calculated as a function of settled organic matter to the sediments, termed "calculated" sediment oxygen demand. Sediment oxygen demand from sources prior to the critical period is assigned during the modeling process. Total sediment oxygen demand is the sum of the "calculated" and "assigned" sediment oxygen demand. See Administrative Record at 0001258-0001260.

<sup>88</sup> See Administrative Record at 0001510.

<sup>89</sup> See Administrative Record at 0005057 and 0005061.

<sup>90</sup> See Administrative Record at 0000011-0000070 and 0004764.

“It appears the SOD is a *‘fudge’ factor* (emphasis added) in this modeling exercise. Please explain the substantial decrease in SOD from calibration to validation.”<sup>91</sup>

Reductions to the assigned sediment oxygen demand should be viewed as a nonpoint source reduction required outside the period of critical summer low-flow. This assigned sediment oxygen demand is meant to reflect the organic matter delivered to the ditch during high flow periods (e.g., spring runoff from nonpoint sources) that settles and subsequently decays and consumes oxygen in the sediment during the critical low-flow period when dissolved oxygen levels are already low.<sup>92</sup> As stated in the QUAL2K User’s Manual, because of “the presence of organic matter deposited prior to the summer steady-state period (e.g., during spring runoff), it is possible that the downward flux of particulate organic matter is insufficient to generate the observed SOD.”<sup>93</sup> In such cases, a supplementary SOD can be prescribed.”<sup>94</sup> This supplementary or assigned sediment oxygen demand reflects organic material delivered to the water body during runoff events (i.e., nonpoint source loads) that occur prior to critical summer low-flow periods. This process is important in properly linking low dissolved oxygen levels that occur in critical summer low-flow periods, to nonpoint source runoff during wetter or higher flow periods of the year.

The importance of this assigned sediment oxygen demand in demonstrating compliance with water quality standards is also noted below from an additional model run completed with the TMDL model.<sup>95</sup> If no assigned sediment oxygen demand reduction was used in the TMDL scenario, the minimum dissolved oxygen calculated by the model upstream from the Kennett WWTP is 4.7 mg/L and downstream would be 4.0 mg/L (i.e., less than the dissolved oxygen standard).

### **C. Significant Reductions to Nonpoint Source Pollutant Loadings are Required to Attain Water Quality Standards**

Significant reductions in nonpoint source loadings are critical for demonstrating water quality standards attainment in Buffalo Ditch. In addition to pollutant load reductions from the Kennett WWTP, the TMDL model scenario included reductions to existing upstream and downstream nonpoint sources as shown in Table 2.<sup>96</sup> The TMDL model scenario represents upstream and downstream nonpoint source load reductions ranging from 46-86% for total nitrogen, 38-78% for total phosphorus and 77-96% for total suspended solids (Table 3).<sup>97</sup>

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<sup>91</sup> See Administrative Record at 0004764.

<sup>92</sup> See Administrative Record at 0001260.

<sup>93</sup> *Id.*

<sup>94</sup> *Id.*

<sup>95</sup> Additional model run was generated from the model provided in the Administrative Record at 0005057.

<sup>96</sup> See Administrative Record at 0005057 and 0005061.

<sup>97</sup> *Id.*

These major reductions in nonpoint source loadings are critical in demonstrating water quality standard compliance through the modeling results. The dissolved oxygen calculated by the TMDL model upstream from the Kennett WWTP is 1.9 mg/L and downstream would be 3.3 mg/L (i.e., less than the water quality standard) if pollutant reductions are only applied to the Kennett WWTP (i.e., if only the TMDL wasteload allocations are applied and there are no reductions to nonpoint sources and the assigned sediment oxygen demand).<sup>98</sup>

**Table 2.** Pollutant Loads Assigned in the TMDL Model for Calibration and TMDL Compliance<sup>99</sup>

Pollutant	Calibration Model Representative of Existing Conditions			TMDL Model Scenario Used to Show Compliance with Water Quality Standards		
	Upstream Nonpoint Source	Downstream Nonpoint Source	Kennett WWTP	Upstream Nonpoint Source	Downstream Nonpoint Source	Kennett WWTP
TN (lbs/d)	7.2	88.1	101.2	3.9	11.9	9.6
TP (lbs/d)	2.1	8.0	25.3	1.3	1.8	1.5
TSS (lbs/d)	172.9	1,333	260.7	39.3	52.3	42.1
Flow (cfs)	2.0	2.7	1.2	2.0	2.7	2.17

Notes: TN = Total Nitrogen, TP = Total Phosphorus, TSS = Total Suspended Solids

**Table 3.** TMDL Load Percent Reduction from Calibration (Existing) Conditions

Pollutant	Upstream Nonpoint Source	Downstream Nonpoint Source	Kennett WWTP
TN	46%	86%	91%
TP	38%	78%	94%
TSS	77%	96%	84%

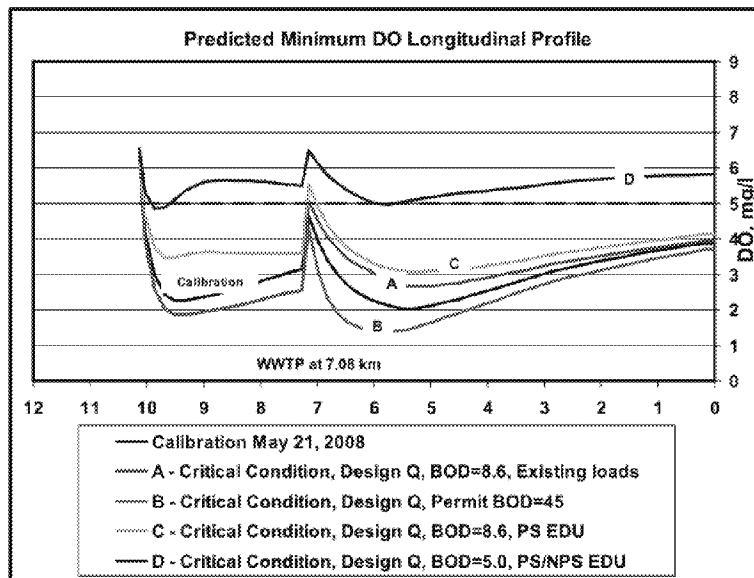
Notes: TN = Total Nitrogen, TP = Total Phosphorus, TSS = Total Suspended Solids

The model results included within the TMDL itself clearly demonstrate the need for significant nonpoint source reductions to demonstrate water quality standards attainment. Figure C-5 of the TMDL (shown below as Figure 6), shows significant improvements in dissolved oxygen levels throughout Buffalo Ditch (both upstream and downstream of the Kennett WWTP) for the final TMDL model compliance run (depicted as 'D' in TMDL Figure C-5) relative to model runs A through C, which represent various levels of point source controls.<sup>100</sup> Therefore, these modeled improvements to demonstrate standard attainment relies on nonpoint source reductions included within the model inputs.

<sup>98</sup> Results based on additional model run generated from the model provided in the Administrative Record at 0005057.

<sup>99</sup> See Administrative Record at 0005057 and 0005061.

<sup>100</sup> See Administrative Record at 0000070.



**Figure 6.** Spatial Profiles of Minimum Dissolved Oxygen for Various Simulation TMDL Model Scenarios (TMDL Figure C-5)<sup>101</sup>

#### **D. TMDL Lacks Reasonable Assurance that Reductions to Sediment Oxygen Demand and Nonpoint Source Pollutant Loadings will be Achieved**

Reasonable assurance applies to a TMDL where the point source wasteload allocation is assigned based on the assumption that nonpoint source reductions in the load allocation will occur (40 CFR § 130.2(i)).<sup>102</sup> Without reasonable assurance, there can be little confidence that water quality standards will be achieved or implemented. USEPA’s 2010 decision document states that “[r]easonable assurances are not required within this TMDL because all permitted point sources have received a WLA that is set to meet [water quality standards]”.<sup>103</sup> However, as previously discussed, without nonpoint source reductions, the WLA assigned in the TMDL will not attain water quality standards.

The TMDL model scenario that demonstrates water quality standards compliance included reductions in the assigned sediment oxygen demand rate ranging from 93-98%, which represents a nonpoint source reduction (see Section III-B). Additionally, the TMDL model included reductions in nonpoint source nutrient and total suspended solids loadings ranging from 38-96% (see Section III-C). Without such reductions from nonpoint sources, the wasteload allocations assigned to the Kennett WWTP will not meet water quality standards. Despite the necessary nonpoint source reductions identified in the TMDL model, reasonable assurances for the nonpoint source reductions are not provided in the TMDL.

<sup>101</sup> *Id.*

<sup>102</sup> See Administrative Record at 0000009.

<sup>103</sup> *Id.*

## **E. TMDL Does Not Demonstrate Water Quality Standards Attainment During Critical Conditions**

The TMDL asserts that summer low-flow conditions are the targeted critical conditions and during these conditions there will be no flows or loads from nonpoint sources.<sup>104</sup> It is during these critical low-flow conditions that the integrity of aquatic communities is considered most threatened.<sup>105</sup> Furthermore, the TMDL states that establishing the wasteload allocation for the Kennett WWTP under critical low-flow conditions when discharges from this facility dominate stream flow serves as an implicit margin of safety.<sup>106</sup>

Although the TMDL asserts that the wasteload allocation for the Kennett WWTP was established under critical low-flow conditions, the TMDL model used for allocating pollutant loads included significant flow contributions from nonpoint sources. USEPA's TMDL model included headwater and lateral inflows (i.e., nonpoint source flows) throughout the entire modeled reach of Buffalo Ditch.<sup>107</sup> Modeled nonpoint source flows ranged from 1.3 cubic feet per second (cfs) entering the ditch from upstream to an additional 3.4 cfs entering the ditch along its length (Figure 7).<sup>108</sup> Relative to the Kennett WWTP flow rate of 2.2 cfs, modeled nonpoint source flows accounted for the majority of flow throughout most of Buffalo Ditch.

As the TMDL model (i.e., tool to demonstrate water quality standards attainment) included significant flow from nonpoint sources, the wasteload allocation for the Kennett WWTP was not established under critical low-flow conditions. Therefore, the stated implicit margin of safety (i.e., use of critical low0flows) was not used to calculate the wasteload allocation. Additionally, running the TMDL model under critical low-flow conditions described in the TMDL does not show compliance with the dissolved oxygen standard.<sup>109</sup>

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<sup>104</sup> See Administrative Record at 0000034.

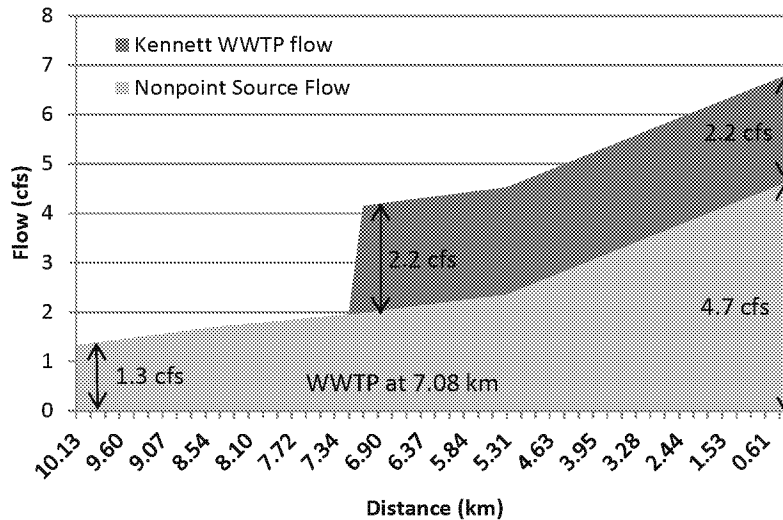
<sup>105</sup> See Administrative Record at 0000033.

<sup>106</sup> See Administrative Record at 0000037.

<sup>107</sup> See Administrative Record at 0005057.

<sup>108</sup> *Id.*

<sup>109</sup> Additional model run was generated from the model provided in the Administrative Record at 0005057.



**Figure 7.** TMDL Model Flows for Critical Low-Flow Condition<sup>110</sup>

### III. Summary

We were retained by Evans & Dixon, LLC who are counsel for the Plaintiff, the City of Kennett, Missouri. We received approximately \$30,000 to prepare this report. We were retained to provide explanation of the Buffalo Ditch TMDL. In undertaking this task, we were asked to examine and review the Administrative Record produced by the USEPA in this case.

The Buffalo Ditch TMDL record contains a significant amount of information that demonstrates the TMDL was not adequately established to implement Missouri's water quality standards assigned to this water body. This finding is supported by the explanations provided in this report, which are summarized below:

1. "Background" conditions prevent attainment of Missouri's minimum dissolved oxygen standard of 5 mg/L in Buffalo Ditch, as well as, other nearby ditches. This is evident as dissolved oxygen measurements taken as part of the TMDL process upstream of the Kennett WWTP and in nearby ditches without a WWTP do not attain water quality standards.
2. The TMDL model demonstrates that significant reductions (over 90%) in sediment oxygen demand are required to achieve MDNR's minimum dissolved oxygen standard of 5 mg/L. However, reductions in sediment oxygen demand are not required or even discussed in the TMDL document. Without reductions in sediment oxygen demand due to nonpoint sources, the TMDL model demonstrates that water quality standards will not be attained or maintained as required by 40 CFR § 130.7(c)(1).

<sup>110</sup> Figure generated from TMDL compliance scenario model in the Administrative Record at 0005057.

3. The TMDL model demonstrates that significant nonpoint source reductions in nutrients and total suspended solids (38%-96%) are required to demonstrate water quality standards attainment with the TMDL model. Without reductions in nonpoint source loadings, the TMDL model demonstrates that water quality standards will not be attained or maintained as required by 40 CFR § 130.7(c)(1).
4. The TMDL does not include reasonable assurances as required by 40 CFR § 130.2(i). The TMDL model clearly demonstrates that significant reductions in sediment oxygen demand and nonpoint source loads are required to attain MDNR's minimum dissolved oxygen standard of 5 mg/L. Without such reductions, the TMDL wasteload allocations alone will not meet water quality standards. Therefore, reasonable assurances are required to ensure that nonpoint source load reductions will occur.
5. The TMDL asserts that the wasteload allocations set by the TMDL model (i.e., tool to demonstrate water quality standards attainment) were established under critical low-flow conditions (i.e., zero nonpoint source flow). However, the TMDL model demonstrates that the wasteload allocations were not established under critical low-flow conditions as the model included significant flow contributions from nonpoint sources. Therefore, the TMDL was not established under critical conditions as required by 40 CFR § 130.7(c)(1) and did not incorporate critical low-flow conditions as an implicit margin of safety. Additionally, running the TMDL model under critical low-flow conditions described in the TMDL does not show compliance with the dissolved oxygen standard.

/s/ John Stober

John Stober, PE  
HDR

/s/ Andrew Thuman

Andrew Thuman, PE  
HDR

**ATTACHMENT A**

**CURRICULA VITAE**

**JOHN STOBER AND ANDREW THUMAN**



## EDUCATION

Master of Science, Civil Engineering, University of Missouri, 1993

Bachelor of Science, Mechanical Engineering, University of Missouri, 1991

## REGISTRATIONS

Professional Engineer, Missouri, United States, No. 029681,

## PROFESSIONAL MEMBERSHIPS

Water Environment Federation, Nonpoint Sources Committee Chair, 2005

Missouri Water Environment Association, President, 2004-2005, Government Affairs Chair, 2004-2005

# John Stober, P.E.

Vice President

Mr. Stober has over 20 years of experience in water quality assessment and regulatory projects and has extensive experience in National Pollutant Discharge Elimination System (NPDES) permitting, Total Maximum Daily Load (TMDL) development and review, quality compliance assessment, watershed assessment and monitoring, wasteload allocations, stormwater runoff characterization and treatment, and Best Management Practices (BMP) design and evaluation. Mr. Stober has managed projects involving development of water quality-based discharge limitations, assessment of beneficial uses and their attainability, development of site-specific water quality criteria, watershed management, and water quality monitoring. These projects include some of most intensive water quality monitoring projects in the Midwestern United States and used state-of-the-art water quality and flow monitoring technologies. Mr. Stober is also actively involved, through various national and local trade organizations, as a stakeholder shaping water quality policies and regulations, at both the State and Federal levels.

## RELEVANT EXPERIENCE

### Integrated Planning Support, City of Springfield, Missouri

Mr. Stober is serving as Project Manager for Springfield's Integrated Planning efforts focused on the City's wastewater, stormwater, water, electric, and solid waste utilities. Under his direction, HDR has assessed timing and magnitude of environmental drivers and piloted a means of prioritizing opportunities using HDR's Sustainable Return on Investment (SROI) methodology based on the triple-bottom-line. This opportunities analysis included evaluation costs and benefits of stormwater controls, differing levels of sanitary sewer overflows, and enhanced nutrient removal. Mr. Stober's team is currently developing a comprehensive environmental database, prioritizing pollution sources using multiple criteria decision analysis, and performing a data gap analysis for future studies.

### Water Quality and Stormwater Regulatory Support, City of Springfield, Missouri

Mr. Stober has served as Project Manager for various regulatory support efforts, including water quality impairments, TMDL studies, regulatory policy, and wastewater and stormwater infrastructure planning. The City of Springfield has several impairments and TMDLs that impact both their wastewater and stormwater programs. Impairment and TMDL parameters include bacteria, nutrients, and aquatic life communities (macroinvertebrates). Mr. Stober developed and managed technical reviews of each of these drivers and provided insight into long-term impacts to the City's water quality programs. He also provided regulatory support through several state water quality standards and permitting rulemakings, as well as, standards impairment decisions.

### TMDL Assessment Services, City of Bentonville, Arkansas

Mr. Stober served as project director to assist the City of Bentonville to assess the Town Branch TMDL. The Town Branch TMDL included total phosphorus allocations for wastewater treatment plant effluent and urban stormwater discharges. The

project consisted of planning and assessment services in addition to discussions with the Arkansas Department of Environmental Quality and EPA Region 6. Ultimately a revised TMDL was developed to provide appropriate water quality targets for aquatic life protection, which mitigated impacts to the City.

**Lake Nutrient Criteria Development, Metropolitan St. Louis Sewer District, Cities of Springfield and St. Joseph, Missouri**

Mr. Stober is aiding development of the State of Missouri's lake nutrient criteria in collaboration with the Missouri Departments of Natural Resources and Conservation to address USEPA's disapproval of previous criteria. The novel approach under development focuses on algal productivity (response variable) criteria tied to aquatic life and drinking water uses. The criteria package also sets screener values for nitrogen and phosphorus that trigger evaluations to determine if uses are impaired based on harmful algal blooms and actual drinking water and aquatic life impacts. Mr. Stober's team has aided development of proposed criteria, rule language, and technical supporting documents.

**Ammonia and Nutrient Removal Master Plan, Metropolitan St. Louis Sewer District, St. Louis, Missouri**

Mr. Stober is serving as the regulatory lead for the District's upcoming Ammonia and Nutrient Removal Master Plan, which will lay out the treatment and regulatory strategies to address ammonia and nutrient drivers. The District currently discharges a combined average of 330 mgd from their seven treatment plants.

**Facility Planning and Water Quality Permitting, Little Blue Valley Sewer District**

Mr. Stober led water quality permitting and critical input to the facility planning for the Little Blue Valley Sewer District's Atherton Wastewater Treatment Plant (50 mgd) and collection system upgrades. Impacts of future State and Federal regulatory drivers were assessed for the project design team led by HDR, including revisions to nutrient, ammonia, bacteria, and wet weather regulations. Mr. Stober also led permit renewal negotiations with critical changes to water quality based permit limitations and bypass provisions.

**Confidential Site-Specific Water Quality Criteria Study, Confidential Power Industry Client**

Mr. Stober is serving as Project Director for development of site-specific sulfate and chloride water quality criteria. The confidential power industry client discharges cooling waters originating from source waters that contain naturally high levels of sulfate and chloride. The discharge also contains constituents that mitigate sulfate and chloride toxicity compared to Federal and State water quality criteria. Geosyntec is developing site-specific criteria using a Water Effects Ratio approach using both chronic and acute whole effluent toxicity testing. The study also includes evaluation of treatment and discharge alternatives and assessment of instream biologic communities.

**Main Ditch Wasteload Allocation Study and Use Attainability Analysis, City of Poplar Bluff, Missouri**

Mr. Stober directed wasteload allocations studies as well as an aquatic life use attainability analysis for Main Ditch on behalf of the City of Poplar Bluff, Missouri, which is under enforcement actions by the MDNR related to its wastewater discharge. This project was initiated after the City received quite stringent NPDES permit limitations based on dissolved oxygen, ammonia and narrative criteria associated with implementation of a TMDL. Mr. Stober's team reevaluated the water quality modeling used to set the dissolved oxygen TMDL, using more sophisticated modeling

techniques. The receiving stream can also support only a limited warm water aquatic community due to severe habitat limitations and historic hydrologic modifications. These factors coupled with potential substantial and widespread socio-economic impacts support an aquatic life use attainability analysis. To support the UAA, Mr. Stober's team conducted habitat assessments, biologic monitoring and collected long-term continuous dissolved oxygen data in both reference, control and study streams.

**Antidegradation Review, Little Blue Valley Sewer District, Middle Big Creek Wastewater Treatment Facility, Pleasant Hill, Missouri.** Mr. led the antidegradation and NPDES permitting for the Middle Big Creek Wastewater Treatment Facility expansion project. Initial regulatory issues facing the proposed expansion included a receiving stream with low in-stream dissolved oxygen levels and little reaeration and addressing the Big Creek total suspended solids (TSS) total maximum daily load (TMDL). This effort included data collection activities, data analysis, water quality modeling, and an antidegradation review and TSS impact report, which ultimately gained approval from the Missouri Department of Natural Resources.

**Missouri Nutrient Trading Framework, Conservation Innovation Grant, St. Louis MSD, Missouri Corn Growers Association, USDA NRCS.**

Mr. Stober led an evaluation the feasibility of a nutrient trading program in Missouri and developed a framework for a market-based nutrient trading program. This study included simulated trading scenarios to evaluate the impacts of several key programmatic decisions on nutrient trading in Missouri. In addition, Mr. Stober's team evaluated cost-effectiveness of municipal wastewater and stormwater treatment and agricultural best management practices to understand economic incentives and drivers.

**Wasteload Allocation and Site-Specific Criteria Development Studies, City of Blue Springs and City of Milan, Missouri**

Mr. Stober managed complex wasteload allocation studies for several municipalities including the City of Blue Springs and the City of Milan. As part of the most detailed wasteload allocation monitoring and modeling studies completed in Missouri, he developed site-specific dissolved oxygen criteria, collected an extensive amount of discrete and continuous water quality data to support water quality model calibration. Project tasks included modelling hydrology, water quality, and sestonic algae within this stream system using the QUAL2K and QUAL2E water quality models, determining wasteload allocations, and deriving water quality-based effluent limitations. The Sni-A-Bar Creek and East Fork Locust Creek site-specific dissolved oxygen criteria were the first approved such criteria approved within the State of Missouri.

**Cuivre River Water Quality Assessment, St. Louis Homebuilders Association, Lincoln County, Missouri**

Mr. Stober led a complex evaluation of the potential water quality impacts of expanded and new wastewater discharges to a large portion of the Cuivre River basin. His team developed a unique modeling framework was developed to be used for watershed-based permitting within the Cuivre River basin and to also identify areas most sensitive to wastewater inputs. The project also included calibration of a water quality model (WASP) for the Cuivre River segment receiving discharges from the Cities of Troy and Moscow Mills, Missouri.

**Missouri Corn Growers Association (MCGA) Watershed Research, Assessment**

**and Stewardship Project, MCGA/MDNR/Syngenta Crop Protection/USDA**

Mr. Stober served as Project Manager of the 5-year Missouri Corn Growers Association (MCGA) Watershed Research, Assessment and Stewardship Project, funded by MCGA, MDNR, Syngenta Crop Protection and the USDA. Under a tight timeframe, he successfully coordinated field efforts and logistics of one of the most data intensive water quality studies in the Midwest. This study included lake and stream water quality assessments within watersheds covering over 500,000 acres. Several land use best management practices were evaluated to determine the most cost-effective and technically sound means to restore impaired water bodies. Mr. Stober deployed and developed unique monitoring systems at approximately 50 water quality monitoring stations. Approximately 800-1200 water quality samples were collected each year for pesticide, nutrient and solids analyses. Data collected during this project was used to delist two major reservoirs (Mark Twain Lake and Smithville Lake) from the 303d list of impaired water bodies. This study also resulted in one of the most robust datasets for herbicide reductions by non-structural agricultural BMPs.

**Antidegradation Review, Kansas City Water Services Department, KC Fishing River Wastewater Treatment Plant, Kansas City, Missouri.** Mr. Stober led the antidegradation review and NPDES permitting for the KC Fishing River Wastewater Treatment Plant expansion project. Mr. Stober's team performed extensive field data collection efforts, which included a time-of-travel dye study and characterization of the stream diurnal dissolved oxygen profile. Additionally, this effort included data analysis and receiving water quality modeling to support antidegradation review.

**Urban Stormwater TMDL Support, Various Local Governments and Institutions, Missouri and Arkansas**

Mr. Stober has managed or directed several technical and regulatory support projects involving urban stormwater TMDLs, water quality impairments, and physical, chemical and biological monitoring for Municipal Separate Storm Sewer System (MS4) permittees. Past and present clients include the Metropolitan St. Louis Sewer District (St. Louis MSD), City of Kansas City, MO, City of Springfield, MO, City of Columbia, MO, Boone County, MO, University of Missouri, City of Kirksville, MO, City of Bentonville, AR, and City of Fulton, MO. Impairment parameters of concern have included sediment, bacteria, chlorides, dissolved oxygen, nutrients, and biologic endpoints. Several of these projects also included reviews of USEPA's increasing approach of using stormwater volume (in addition to flow) as a surrogate for water quality parameters of concern, as well as aggressive nutrient targets.

**Two-Mile Prairie Stream Water Quality Assessment, University of Missouri, USEPA**

Mr. Stober served as Project Director for the Two-Mile Prairie stream water quality assessment in Southern Boone County, Missouri. This project included evaluation the potential water quality impacts caused by municipal wastewater discharge from a rapidly growing area. The project location is within very sensitive watersheds and ecoregions, including potential habitat for an endangered species. The project team collected extensive water quality monitoring data (including continuous and discrete flow and water quality monitoring) to calibrate and validate a water quality model (QUAL2K). The water quality model was utilized to evaluate potential water quality impacts for various discharge flow and quality scenarios. Continuous dissolved oxygen data were also collected within control streams for future development of site-specific dissolved oxygen criteria.

**Sni-A-Bar Creek Wasteload Allocation Study, City of Oak Grove, Missouri**

Mr. Stober provided water quality consulting and permit negotiation services for the numerous municipalities throughout Missouri, including the City of Oak Grove. The City was presented very strict discharge limitations during planning of a new wastewater treatment plant. Mr. Stober steered the City toward a new discharge location that provided additional stream assimilative capacity and developed a revised wasteload allocation for MDNR consideration, which was supported by a QUAL2E model.

**Southwest Missouri Water Quality Improvement Project, ERC/USEPA/Various Watershed Organizations**

Mr. Stober served as Project Director for the Data Gap Analysis of the Southwest Missouri Water Quality Improvement Project. Mr. Stober's multi-organization team collected available data, organizing a project database and evaluating data gaps for the watersheds of the James, Sac, Elk and Spring Rivers, as well as Table Rock Lake which supports an over \$1 Billion tourism industry. Over 500,000 pieces of water quality data from numerous sites and sources were gathered for evaluation. Nutrients, bacteria, and metals were considered pollutants of concern for these assessments. Water quality data interpretations and prioritized data gaps were being prepared for these basins.

**Antidegradation Review, Columbia Regional Wastewater Treatment Plant, Columbia, Missouri.** Mr. Stober led the water quality and antidegradation review for the City of Columbia wastewater treatment plant expansion from 20.6 to 25.2 MGD. The water quality and antidegradation review consisted of complex discharge scenarios which included 1) discharging to an adjacent conservation area, 2) indirectly discharging to the Missouri River and 3) directly discharging to the Missouri River. Permitting efforts work coordinated with the Missouri Department of Conservation who owns and manages the conservation area adjacent to the City's treatment wetlands and derivation of appropriate water quality-based effluent limitations.

**Antidegradation Review, Metropolitan St. Louis Sewer District, Missouri River Treatment Plant, St. Louis, Missouri.** Mr. Stober led the water quality and antidegradation review for the District's Missouri River Wastewater Treatment Facility expansion from 28 to 38 MGD. The Missouri River Wastewater Treatment Facility antidegradation review was one of the first antidegradation reviews completed in the State of Missouri. Through this project, Mr. Stober helped develop precedent setting procedures for demonstrating insignificance where Missouri's Antidegradation Implementation Procedures lacked details.

**Water Quality Permitting, St. Louis MSD, Little Blue Valley Sewer District, City of Jefferson, City of St. Joseph, City of Independence, and City of Hermann, Missouri**

Mr. Stober led water quality permitting and regulatory support to St. Louis MSD, the Little Blue Valley Sewer District, the City of Jefferson, the City of St. Joseph, the City of Independence and the City of Hermann, Missouri regarding their permitted discharges to the Missouri River. These efforts guided Missouri's policies and regulatory changes related to bacteria water quality standards and water quality-based permit limitations collectively for these discharges to large receiving waters. He also provided individual permitting support and guidance for several of these clients

**NPDES Metals Translator and Biotic Ligand Modeling Study, City of Lebanon**

**Missouri**

Mr. Stober served as Project Director for a metals translators and biotic ligand modeling study to modify the City of Lebanon's NPDES permit limitations for copper and zinc. The translator study included evaluation of dissolved and total recoverable metals fractions to refine overly conservative permit limit derivation assumptions. Geosyntec developed an approved Quality Assurance Project Plan to execute data collection efforts, including use of trace metals field and laboratory methods. A biotic ligand model was also developed to evaluate the potential for successfully developing site-specific water quality criteria.

**Technical and Regulatory Support, St. Louis Homebuilders Association, St. Louis MSD and REGFORM, St. Louis, MO**

Mr. Stober provided technical and regulatory support to the St. Louis Homebuilders Association, St. Louis MSD and REGFORM, providing formal comments to proposed Missouri Water Quality Regulations and during development of Missouri's Antidegradation Implementation Procedures. Mr. Stober represented these entities within numerous stakeholder meetings and provided testimony at several public hearings. These efforts helped guide substantial regulation and policy developments, included one of the most comprehensive antidegradation implementation procedures in the United States.

**Integrated Stormwater Master Plan and MS4 Program Support, University of Missouri, Columbia, MO**

Mr. Stober is serving as Project Manager for development of the University of Missouri's integrated stormwater master plan. This project includes reassessment of existing and development of new post-construction stormwater control measures to meet MS4 NPDES obligations. Typical BMP designs and sizing criteria will be developed for use at new building projects, as well as potential retrofit opportunities. The integrated plan will also include evaluation of existing stormwater problem areas and potential opportunities to retrofit both building site and regional BMPs. The Stormwater Management Model (SWMM) will be used to size site level and regional BMPs within one subwatershed and evaluate the stormwater improvements. The integrated plan will also take into account local TMDL drivers.

**Metropolitan St. Louis Ambient Water Quality Monitoring, St. Louis MSD, St. Louis, Missouri**

Mr. Stober led a multi-year water quality monitoring and assessment effort including collection surface water samples at 16 ambient water quality monitoring stations, ranging from small urban streams to some of the largest rivers in the US. The project team evaluated the water quality and flow data to characterize both baseflow and wet weather water quality conditions. Various physical, chemical and biologic data were gathered during this extensive monitoring effort, including low level metals analyses. Mr. Stober's project team also developed a comprehensive water quality database for historic and future data.

**Water Quality Studies, AmerenUE/Department of Energy, Lake of the Ozarks, Missouri**

Mr. Stober served as Project Manager of the water quality studies, initiated in Spring 2001, related to the relicensing of Bagnell Dam, which impounds the Lake of the Ozarks, a major recreational reservoir in Missouri. The main focus of the water quality studies are related to low dissolved oxygen conditions produced by discharge of hypolimnetic waters through the hydroelectric facility. Several continuous dissolved oxygen monitoring stations have been maintained over the last 9 years to assess compliance with the designated use of protection of the warm water fishery.

The appropriateness of this designated use and the resulting dissolved oxygen criteria were reviewed with respect to biological data collected during 2001. In addition, the basis of the Federal and State dissolved oxygen criteria were reviewed. This project has drawn significant comments and negotiations with the MDNR, Missouri Department of Conservation (MDC), United States Fish and Wildlife Service, and American Fisheries Society. Mr. Stober also led the firm's evaluation of new and existing turbines, which are enhanced with additional aeration capabilities. This study, funded by AmerenUE and Department of Energy, is the first comprehensive field study of turbine aeration enhancements.

#### **Agricultural Best Management Practice Evaluation, ERC, Shelby, Missouri**

Mr. Stober served as Project Director for a research-driven edge of field Best Management Practice (BMP) study for the Natural Resources Conservation Services and Environmental Resources Coalition. Project elements included experimental design, coordination and quality assurance of continuous hydrologic, water quality, and meteorological data collected within wetland and subsurface bioreactor settings.

#### **PROFESSIONAL EXPERIENCE**

HDR, Columbia, Missouri, Vice President, 2013 – Present

Geosyntec Consultants, Columbia, Missouri, Principal, 2009 - 2013

MEC Water Resources, Columbia, Missouri, President, 2003 – 2009

Midwest Environmental Consultants, Jefferson City, Missouri, President, 1992-2003

#### **AWARDS AND RECOGNITIONS**

Arthur Sidney Bedell Award, Water Environment Federation, 2007

Watershed Management Award, Missouri Water Environmental Association, 2011

#### **PUBLICATIONS**

Stober, J.T., Kemper, E., Bill, E., Dove, E., Christiansen, J., 2015. Prioritizing the Springfield – Greene County Integrated Plan Opportunities Based Upon the Sustainable Return on Investment. Proceedings of the Water Environment Federation, WEFTEC 2015.

Stober, J.T.; Kemper, E.; Dove, E., 2013. Flow-Based Total Maximum Daily Loads: Missouri Experiences. Proceedings of the Water Environment Federation, WEFTEC 2013: pp. 2991-3001.

Ishida, C.K.; Strecker, E.; Stober, J.T.; Bardol, M.; Quigley, M., 2011. Regional Applications of Multiple Strategies for Sustainable Water Resources Management. Proceedings of the Water Environment Federation, WEFTEC 2011: pp. 4395-4405.

Ishida, C.; Grantham, R.; Stober, J.T.; Willobee, M.; Quigley, M.; Reidy, P.A., 2011. Regional Cost-Benefit Analysis of Rainwater Harvesting: Sustainable Economics to Justify Green Technologies. Proceedings of the Water Environment Federation, Collection Systems 2011, pp. 454-461(8).

Stober, J.T.; DeGrate, O.; Christopher, S.; Zell, C., 2010. Sni-A-Bar Creek Water Quality Study: Development of Site-Specific Criteria, Wasteload Allocations and Antidegradation Review. Proceedings of the Water Environment Federation, WEFTEC 2010, pp. 5066-5091.

Ishida, C.K.; Petropoulou, C.; Stober, J.T.; Steets, B.; Strecker, E.; Chatti, D.; Salveson, A., 2009. Evaluating Greywater for Unrestricted Reuse. Proceedings of the Water Environment Federation, WEFTEC 2009, pp. 1863-1869.

**PRIOR LITIGATION SUPPORT**

Expert Witness on Behalf of Poplar Bluff Municipal Utilities and City Cable to Missouri  
Administrative Hearing Commission regarding Poplar Bluff NPDES Permit Appeal  
(MO-0043648), Appeal No. 10-0017 CWC.





## Andrew J. Thuman, PE

Vice President, Water Quality Practice Lead

### EDUCATION

ME Environmental  
Engineering, Manhattan  
College, 1990

BE Civil Engineering,  
Manhattan College, 1988

### PROFESSIONAL REGISTRATION

Professional Engineer: New  
Jersey

### PROFESSIONAL MEMBERSHIP

Water Environment Federation  
(WEF)

American Society of Civil  
Engineers (ASCE)

National Council for Air &  
Stream Improvement (NCASI)

### PROFESSIONAL EMPLOYMENT HISTORY

HydroQual, Inc. (1990-2010)  
HDR (2011-present)

Mr. Thuman has 24 years experience conducting water quality modeling studies in rivers, lakes, estuaries and their associated watersheds. The majority of these projects were completed to develop point source effluent limits (i.e., water quality based effluent limits - WQBEL) as part of NPDES permitting but have also included TMDL development to address nonpoint sources. These efforts have included water quality modeling to assess the impact of point source discharges, determining allowable effluent limits, assisting in negotiating permit limits, providing litigation support as part of permit challenges, and the preparation of technical reports/presentations to support the permitting process.

The water quality modeling frameworks used on these projects range from systems involving pathogen fate and transport; BOD oxidation, nitrification and diurnal algal impacts on steady-state dissolved oxygen (DO) concentrations; to state-of-the-art, time-variable coupled hydrodynamic and water quality models to investigate pathogens and nutrient related eutrophication issues. Mr. Thuman has used the QUAL2E/K, DIURNAL and CE-QUAL-W2 river/lake water quality models to develop wasteload allocations (WLA) as well as more complicated estuarine hydrodynamic and water quality models (EFDC/WASP, ECOM/RCA) as part of TMDL development and facility planning projects. In addition, he has used the following watershed models to address nonpoint sources: HSPF, LSPC and GWLF.

Mr. Thuman has been involved in TMDL development and review in the States of Delaware, Florida, Pennsylvania, New Hampshire, Mississippi, New Jersey, New York, Maine, Washington, Virginia, Georgia, North Carolina, South Carolina, Utah, Minnesota, Wisconsin, Indiana, Montana, California, Connecticut and Puerto Rico. These projects have involved the various aspects of TMDL development ranging from problem identification, source assessment and identification, water quality modeling, TMDL development, documentation and public (stakeholder) participation.

Mr. Thuman also has experience in conducting mixing zone studies and in the application of the initial dilution models CORMIX and Visual PLUMES. These studies included the determination of mixing zones for a variety of toxic pollutants and thermal inputs for existing and proposed discharges as well as for the design of outfall diffusers. He has also been involved in developing field sampling programs, time of travel and reaeration studies in support of water quality modeling projects and has completed compilation, analysis and graphical presentation of riverine and estuarine surface water quality, sediment and hydrodynamic data.

## RELEVANT EXPERIENCE

**Alternate Effluent Limits for Wisconsin Electric Power Company Valley Plant (Milwaukee, WI):** Project Director for a thermal modeling study to develop alternate effluent temperature limits as part of a successful thermal variance request to the Wisconsin DNR. The hydrothermal model (ECOM) include the Milwaukee, Menomonee and Kinnickinnic River, Milwaukee Harbor and near shore Lake Michigan. The hydrothermal model results were used together with a biothermal assessment to show protection of representative important species (RIS) and balanced indigenous community (BIC) as part of the thermal variance documentation.

**Thermal Discharge Modeling for Wisconsin Electric Power Company (Lake Michigan, WI):** Project Director for a thermal discharge study to investigate the thermal discharges from two power plants (Oak Creek/Elm Road) along the shoreline of Lake Michigan. As part of construction of the second power plant and installation of an offshore intake structure, biological monitoring was required to assess impingement and entrainment requirements as part of the 316 permitting process. The thermal modeling completed was used to guide sampling location selection for the biological monitoring.

**Thermal Discharge Modeling for Great Lakes Cheese Facility, Adams, NY:** Project Director for a thermal modeling study of Sandy Creek (trout stream) as part of a SPDES thermal variance request for the thermal discharge from the facility. The time-variable, 2D hydrothermal model MIKE was used to complete the temperature modeling and to develop thermal projections as part of developing alternate effluent temperature limits as part of the thermal variance request to NYSDEC.

**Hydrothermal Model Review and Selection (Niantic Bay/Long Island Sound):** Project Director for the review of six hydrothermal models (including MIKE3D), selection of the most appropriate model and development of a modeling workplan for the Dominion Millstone Power Station (CT) as part of the permit requirements with the Connecticut Department of Energy and Environmental Protection.

**Plant Crist Nutrient Discharge Assessment, Pensacola, FL:** Project Director for a nutrient discharge assessment to support a beneficial water reuse project between Gulf Power and Emerald Coast Utilities Authority (ECUA). A modeling framework of Escambia Bay was used to complete the nutrient assessment for the proposed nutrient discharge from Plant Crist to the lower Escambia River. Based on the modeling completed and assessment of the proposed GP nutrient discharge options to upper Escambia Bay, water quality impacts was negligible and will have little impact on the biology of the bay, as based on the assessment parameters of chl-a, TN and TP.

**Plant Smith Nutrient Discharge Assessment, Bay County, FL:** Project Director for a nutrient discharge assessment to support operation and installation of a selective non-catalytic reduction (SNCR) system at Gulf

Power's Plant Smith to more effectively remove nitrogen oxides (NO<sub>x</sub>) from its atmospheric releases, which results in a nitrogen loading increase from the cooling water discharge to West Bay. A modeling analysis was completed for the assessment and determined that water quality impacts were negligible and have little to no impact on the biology of the bay due to the calculated TN or chl-a increases.

**Discharge Improvement Study (Kankakee River, IL), Exelon:** Project Director for a near- and far-field discharge study to investigate options for improving mixing and dilution of the effluent in the river. The near-field model, CORMIX, and far-field model, ECOMSED, were used to investigate whether improvements to the current bank discharge or installation of a multi-port diffuser in the main flow of the river will achieve complete mixing of the effluent with the river.

**AES Company Thermal Discharge Modeling and Permitting Support for Three NY State Plants: Project Director for thermal criteria studies at three AES plants in NY State:** Westover (Susquehanna River); Somerset (Lake Ontario); and Cayuga (Cayuga Lake). These studies included thermal field studies, hydrothermal modeling (ECOM), SPDES permitting support and general consulting services. The studies were designed for compliance with NYSDEC thermal and CWA 316(a) regulations.

**Escambia Bay Nutrient TMDL/Criteria Development, Escambia Bay TMDL Coalition, FL:** Project Director for the development of a nutrient TMDL and nutrient criteria development efforts in the Escambia/Pensacola Bay system. Upper Escambia Bay was listed by FDEP as nutrient impaired for "historic chlorophyll-a" and, therefore, requiring a TMDL. The initial TMDL completed for the bay was reviewed and comments provided as part of the public comment process. Our comments focused on the specification of the chlorophyll-a target and linkage between nutrient loads and water quality effects in the bay. We completed updates to the existing hydrodynamic (ECOM) and water quality (RCA) modeling system of the Escambia/Pensacola Bay system for use in developing a nutrient TMDL and also assisting FDEP in developing nutrient criteria for the bay as part of their response to EPA nutrient criteria development efforts. Our nutrient criteria development approach focused on nutrient response variables such as available light for seagrass, DO and phytoplankton levels.

**Development of a Coupled Hydrodynamic/Eutrophication Model for Pensacola/ Escambia Bay, International Paper, FL:** Project Manager responsible for the development of a time-variable, three-dimensional, coupled hydrodynamic and eutrophication model of Escambia River & Bay, Pensacola Bay, Blackwater Bay and East Bay to assess the impact on water quality due to a proposed nutrient discharge to the Escambia River from a paper mill near Pensacola, FL. The calibrated model was used to assess the impact of the proposed discharge of nutrients on ambient phytoplankton and DO levels. Proposed nutrient discharge levels were established that maintained the designated uses of the proposed receiving waters.

**St. Andrews Bay WQBEL for the St. Andrews WWTF, FL:** Project Director for the development of a nutrient WQBEL for the St. Andrews WWTF discharge to the main bay segment. The St. Andrews (SA) wastewater treatment facility (WWTF) is in the process of expanding from an effluent discharge flow of 5 to 10 MGD to accommodate future growth. In order to assess the water quality impacts associated with the increased discharge to St. Andrews Bay, a water quality model was used to determine Water Quality Based Effluent Limitations (WQBEL) through the Level II Process. Although St. Andrews Bay is not on the State 303(d) List of Impaired Waters, West Bay is listed for “historic chlorophyll-a” due to TN and TP. Therefore, the water quality impacts associated with the SA WWTF expansion were also assessed in West Bay. Modeling indicated there would be a negligible impact to DO, nitrogen and chlorophyll-a concentrations within the bay from the expansion of the WWTF.

**Bay County/RockTenn Transparency Study, Panama City, FL:** Project Director for a transparency study to assess the impacts of the Bay County Military Point Lagoon treatment system color discharge on ambient light levels in St. Andrews Bay. The Florida DEP transparency standard allows for a 10% change from background ambient light conditions and the St. Andrews Bay hydrodynamic and color model was used to assess compliance with the transparency standard. Field studies were completed to assess current submerged aquatic vegetation (SAV) health and distribution along with providing data for model calibration. The color model was used to show compliance with the transparency standard at the edge of an allowed mixing zone.

**Lafarge Diffuser Design and Thermal Impact Study, Ravena, NY:** Project Director for a diffuser design study related to a new TDS discharge to the Hudson River and the associated SPDES permitting with NYSDEC. In addition, a thermal discharge analysis was completed in Coeyman’s Creek (trout stream) to assess the thermal discharge from the facility and SPDES permitting of new and re-located outfalls on the site.

**Thermal Discharge Modeling for Empire Plaza, Albany, NY:** Project Director for a thermal discharge study as part of NYSDEC SPDES thermal permitting of the discharge from the Empire Plaza cooling plant. The study involved hydrodynamic modeling (ECOM) of the Hudson River, which is still tidal near Albany. The modeling involved field sampling design, calibration to the collected field data and water quality projections to determine the spatial impact of the thermal discharge under permit discharge conditions. Thermal criteria from NYSDEC require assessment of both maximum temperature and temperature rise above background conditions at critical river conditions (low-flow, summer temperature). The resulting thermal modeling projections were used as part of the facilities SPDES permit renewal application.

**American Sugar Refining Inc. (Domino) Thermal Mixing Zone Study, Yonkers, NY:** Project Director responsible for responding to a NYSDEC request for information related to intake and discharge SPDES permitting. This involved gathering existing information and developing a Thermal Study Workplan to gather ambient data for assessing potential thermal impacts

associated with the Domino discharge. The Thermal Study included field monitoring and CORMIX initial dilution modeling to assess existing conditions, develop a thermal mixing zone and provide a maximum discharge temperature limit for the facilities SPDES permitting efforts.

**Kinnickinnic River Flushing Tunnel DO Evaluation, Milwaukee Metropolitan Sewerage District (MMSD), Kinnickinnic River, WI:** Project Director for the DO modeling of the Kinnickinnic River to evaluate the effectiveness of the flushing tunnel operation on maintaining or improving DO levels in the lower Kinnickinnic River. The DO modeling included the effects of planned upstream stream restoration, flushing tunnel rehabilitation and supplemental oxygen injection. The modeling results were combined with biological surveys of the river to recommend the potential options for the District related to the flushing tunnel effectiveness and future management plans for improving DO in the lower Kinnickinnic River.

**Jones Island Non-Contact Cooling Water Discharge Permitting, Milwaukee Metropolitan Sewerage District (MMSD), Kinnickinnic River, WI:** Project Director for the mixing zone/initial dilution modeling to assess temperature impacts associated with the Jones Island WWTP non-contact cooling water (NCCW) discharge to the lower Kinnickinnic River. The initial dilution model CORMIX was used to assess the mixing and dilution of the NCCW discharge for determining allowable effluent temperature limits that will be in compliance with the WDNR temperature standards at the edge of an allowable mixing zone. The modeling results were used to successfully negotiate acceptable effluent limits for the Jones Island NCCW discharge.

**2020 Facility and Regional Planning Study, Milwaukee Metropolitan Sewerage District (MMSD) and Southeast Wisconsin Regional Planning Commission (SEWRPC), Milwaukee Harbor, WI:** Project Director for the 2020 Planning study conducted for MMSD and SEWRPC. HDR|HydroQual's role as a modeling sub-contractor on the study was to apply the existing BSTF hydrodynamic and bacteria models (ECOM/RCA), in addition to developing a eutrophication model, to investigate various facility and regional (watershed) planning activities in the Greater Milwaukee area. These management alternatives included various levels of CSO/SSO control, stormwater BMPs, in addition to agriculture and pasture NPS controls. A unique aspect of the project involved the coupling of upstream watershed models (HSPF and LSPC) to the downstream estuary models (hydrodynamic, bacteria and eutrophication). The upstream watershed models were used to assess the impact of population change, NPS controls and stormwater BMPs. In addition, conveyance system modeling provided CSO/SSO discharge information for various facility upgrades that are planned and proposed. The results of these modeling efforts was the calibration and validation to an 8-year period (1995-2002) and application of the models for water quality projections (production runs) to a 10-year period using 1988-1997 rainfall characteristics. The overall end-product of the 2020 Planning Study was management recommendations for both MMSD facilities and SEWRPC long range planning that is based on water quality impacts as well as other society and economic driven factors.

**Bacteria Source, Transport and Fate (BSTF) Study, Milwaukee Metropolitan Sewerage District (MMSD), Milwaukee Harbor, WI:** Project Director for the BSTF Study conducted for MMSD to investigate the role of various bacteria sources on the distribution of fecal coliform in the Milwaukee Harbor system. The water bodies involved are the Milwaukee, Menomonee and Kinnickinnic Rivers, inner/outer harbor and near-shore Lake Michigan. Initially the study was focused on the impact of CSO/SSO discharges from the MMSD conveyance system but also included bacteria sources due to upstream watershed runoff (urban, agriculture, pasture) and municipal WWTPs associated with the City of Milwaukee. The main areas of concern are local beaches and the resultant beach closings due to elevated bacteria levels. To properly analyze fecal coliform distribution in the study area, a hydrodynamic model (ECOM) was developed and calibrated to represent water circulation due to river flow, meteorology (wind), thermal discharges and offshore lake effects (water level changes). The hydrodynamic model was coupled with a bacteria model (RCA) that included loadings of bacteria in addition to the various die-off mechanisms of fecal coliform. The study involved an extensive review of available monitoring data supplied by MMSD and others in addition to the development of bacteria loads from CSO/SSO, WWTP, and upstream sources. Phase 2 of the study utilized the results of bacteria source tracking information and lab die-off studies collected by the Great Lake WATER Institute (GLWI) in addition to the inclusion of local stormwater runoff loads to enhance the modeling effort. Ultimately, the goal was to develop a predictive tool to assist managers in assessing the impacts of storm events on bacteria levels in high priority areas such as local beaches.

**Forge River TMDL, Town of Brookhaven, Long Island, NY:** Technical Advisor for a DO TMDL in the Forge River to address the listing of the river on the NYSDEC 303(d) impaired waters list. The TMDL model developed included a hydrodynamic model (ECOM) of the river and Moriches Bay that was coupled to a eutrophication model (RCA) for linking nitrogen loadings to algal growth and ultimately DO. A unique aspect of the project was the linking of a groundwater model to the river model to provide freshwater flow and groundwater nitrogen loads to the river model.

**James River TP Overflow Assessment and Model GUI, Hampton Roads Sanitation District (HRSD), VA:** Project Director for a bacteria transport modeling study to assess the potential impacts at area beaches in the James River from an overflow event at the HRSD James River Treatment Plant (TP). HDR|HydroQual's hydrodynamic model (ECOM) of the James River was refined for the analysis and setup to represent the circulation characteristics of the James River around the time of the overflow event. Results from the study indicated that the overflow event had minimal impact on enterococcus levels at area beaches and that levels associated with the overflow event were below VADEQ water quality standards. As a follow-on to the project, HDR|HydroQual is developing a model graphical user interface (GUI) to allow HRSD staff to quickly and easily use the pathogen fate and transport model to assess the water quality impact of overflows throughout

the James River study area.

**Mixing Zone and Diffuser Design for the York River TP, HRSD, VA:** Project Director for a mixing zone study to establish acute and chronic mixing zones for a new outfall for the York River Treatment Plant (TP). The CORMIX initial dilution model was used to design a multi-port submerged diffuser in the tidal York River following VADEQ regulations and guidelines for mixing zones. The project was completed under a very tight design- build schedule due to the closing of a power plant on the York River where the TP was discharging its effluent into the cooling water discharge canal.

**Mixing Zone and Diffuser Design for the King William and West Point TPs, HRSD, VA:** Project Director for two mixing zone studies to establish acute and chronic mixing zones for the existing West Point Treatment Plant (TP) discharge to the Mattaponi River and a new discharge to the Pamunkey River for the King William TP. The initial dilution model CORMIX was used for the dilution analyses with the tidal effects on dilution estimated using the tidal build-up option available in CORMIX. Acute and chronic mixing zones were developed for the existing West Point TP outfall and the newly design King William TP outfall in accordance with VADEQ regulations.

**Initial Dilution Analysis and Diffuser Design for the Army Base TP, HRSD, VA:** Project Manager for a diffuser design study for an upgrade of the HRSD Army Base Treatment Plant (TP) outfall from a submerged open-ended pipe (single-port) to a submerged multi-port diffuser. The goal for the outfall upgrade was to provide additional effluent dilution and to develop a acute and chronic mixing zones for the Army Base TP discharge to the Elizabeth River. The PLUMES initial dilution model was used to complete the diffuser design and effluent dilution analyses. In addition, we worked with KCI Technologies in a subsequent effort related to the final design (submerged wye-diffuser) for the Army Base WWTP outfall.

**Ocean Outfall Dilution and Mixing Zone Studies, City and County of Honolulu, HI:** Project Director for three mixing zone studies to establish acute and chronic mixing zones for the Honouliuli, Waianae and Kailua WWTP ocean outfalls. The Visual PLUMES initial dilution model was used to calculate effluent dilution under critical ambient and discharge conditions for determining acute and chronic dilution factors for use in NPDES permitting and as part of 301(h) secondary treatment waiver requests/renewals at the three ocean outfalls.

**City of Billings Mixing Zone Study, Montana:** Project Director responsible for completing a mixing zone study as a part of MTDEQ permitting of the City of Billings WWTP discharge to the Yellowstone River. Managed the field program design, analysis of data and application of the CORMIX initial dilution model to the field data and determination of site-specific acute and chronic mixing zones for unionized ammonia. Based on the successful application of the CORMIX model to the observed dye study data, it was used to determine final effluent permit limits for the City of Billings WWTP at critical conditions. In addition, this project also entailed developing a TMDL strategy for the City. This TMDL strategy is focused on characterizing water

quality in the Yellowstone River below the discharge, reviewing and commenting on a downstream TMDL that MTDEQ is completing, designing and implementing field studies to collect required TMDL data.

**Murderkill River Watershed Nutrient/DO Criteria and TMDL Model Development, Kent County DPW and DNREC, Dover, DE:** Project Director for the development of watershed and tidal TMDL water quality models for nutrients and DO for a number of river, pond/lake and tidal estuary segments in the Murderkill River watershed. This new effort was aimed at developing site-specific water quality standards for DO and nutrients as part of a multi-disciplinary team including DNREC, Kent County, HDR|HydroQual, Universities of Delaware and Maryland, Stroud Water Research Center and the USGS. HDR|HydroQual developed models of the watershed (HSPF), tidal river hydrodynamics and water quality (ECOM/RCA) to support this effort. These state-of-the-science modeling tools were supported by an extensive monitoring program that included: tidal salt marsh (nutrient dynamics, temperature, LIDAR), algal production (carbon production), sediment flux (SOD and nutrients) studies; project specific tidal and water quality monitoring; and a working Murderkill River Study Group to provide guidance and local information. As part of the effort, site-specific nutrient and DO criteria were developed along with revisions to the existing TMDL.

**TMDL Studies for Blackbird Creek, Smyrna River, Leipsic River, Littler River, St. Jones and Broadkill River Watersheds, DNREC, DE:** Project Director for these approved TMDL projects completed for the Delaware Department of Natural Resources and Environmental Control (DNREC). The projects were completed to develop nutrient, DO and bacteria TMDLs for these six watersheds. As part of these studies, watershed, hydrodynamic and water quality modeling was completed for the ultimate development of TMDLs by the end of 2006. These studies included data analysis (including geographic data from BASINS), watershed (HSPF & LSPC), hydrodynamic (ECOMSED) and water quality (RCA) model development/calibration/validation for a 2-year time period during 2002-2003. Public (stakeholder) meetings were also held throughout the duration of these projects to discuss available data, model development, the TMDL and resulting point source WLAs and nonpoint source LAs.

**Appoquinimink River Watershed TMDL Model Development, DE:** Project Manager for the development and expansion of the existing tidal TMDL model for nutrients and DO. HDR|HydroQual was contracted to expand the existing WASP5 hydrodynamic and water quality model of the Appoquinimink River and its tributaries and ponds. The expanded model was used by DNREC to develop TMDLs that included a WLA for Middletown-Odessa-Townsend wastewater treatment plant point source, a load allocation for nonpoint sources and included a margin of safety.

**Opequon Creek Assimilative Capacity Study, VA:** Project Director for the Opequon Creek Assimilative Capacity Study whose primary objective was to develop a technically defensible water quality model of Opequon Creek to support subsequent wastewater master planning by the Frederick-Winchester Service Authority (FWSA), County and City. As part of the



Opequon Creek Capacity Study, field programs were designed and performed to gather current water quality information in the Opequon Creek watershed in addition to the development of an updated water quality model (DIURNAL) for the creek. Two field surveys of Opequon Creek and major tributaries were completed and an updated water quality model of the creek was used to determine the assimilative capacity of the creek to assist in point source permitting.

**East Canyon Creek TMDL Model Development, Park City, UT:** Project Director for development of the East Canyon Creek TMDL model for the Snyderville Basin Water Reclamation District, which operates the East Canyon Water Reclamation Facility. East Canyon Creek provides the primary drainage from the upper East Canyon watershed to the East Canyon Reservoir and is located near Park City. East Canyon Creek has been listed on Utah's 1998 303(d) list of impaired waters for TP and DO from the creek headwaters to the East Canyon Reservoir. As part of the development of the TMDL model, field programs were designed and performed to gather current water quality information in the East Canyon Creek watershed in addition to the development of a water quality model for the creek. A unique aspect of the creek modeling and TMDL was the recommendation of non-traditional implementation strategies to improve DO levels in the creek. These included increased riparian shading, stream channel restoration and flow augmentation in addition to NPS solids control.

**WQBEL for Elevenmile Creek and Perdido Bay, International Paper, FL:** Project Manager for developing a WQBEL and associated NPDES permitting support for a paper mill near Pensacola. A QUAL2E model of Elevenmile Creek was calibrated and used to develop effluent limits for the option of maintaining an existing discharge location. The downstream end of the model provided boundary conditions for a WASP eutrophication model of Perdido Bay which was used to evaluate the impacts of wastewater discharge on DO in the bay and considered nutrient induced algal effects, and the effects of CBOD oxidation and NH<sub>3</sub> nitrification. These recent studies have included assessing water quality impacts associated with relocation of the discharge along with additional effluent treatment through a natural wetland system. The modeling has also expanded to include a time-variable, 3D model of the Perdido Bay system to assess color impacts associated with the relocated discharge.

**Third Party Nutrient TMDL for the Fenholloway Estuary, FL:** Project Manager for a time variable, 3D hydrodynamic/water quality model (ECOM/RCA) of the Fenholloway Estuary and adjacent coastal zone. Initial review of the EFDC/WASP model application indicated model linkage issues and resulted in application of the ECOM/RCA hydrodynamic/water quality model to complete the nutrient TMDL and associated mill discharge permit limits. Involved the continued and successful coordination with USEPA Region 4, FDEP and the discharger.

**St. Andrew Bay, Phase I Hydrodynamic and Water Quality Modeling, FL:** Project Engineer involved in the Phase 1 development of a coupled hydrodynamic/water quality model of St. Andrew Bay. The model was used

to determine the general circulation aspects of the bay and to assess the impacts of the Bay County WWTP discharge for WLA development. The water quality model addressed the impacts of DO in the bay due to CBOD oxidation, algal production and respiration.

**A Mixing Zone Analysis for a Proposed Perdido Bay Diffuser, FL:** Project Engineer evaluating the mixing associated with various diffuser designs for a proposed wastewater discharge to Perdido Bay. A hydrodynamic model was developed and applied to identify areas of the bay that experienced the greatest mixing. After a site was selected, the CORMIX initial dilution model was used to evaluate the initial dilution for various diffuser designs.

**Mixing Zone Analysis for the Millville WWTP Proposed Diffuser, FL:** Project Engineer for completing a mixing zone study for the Millville WWTP proposed submerged diffuser discharge to St. Andrew Bay. The CORMIX model was employed to address the plume dilution of the proposed discharge of effluent metals at critical (low velocity) mixing conditions to meet ambient water quality standards. The impacts of effluent CBOD and nutrients on dissolved oxygen in the bay were determined based on the calculated plume dilutions of the proposed diffuser.

**Review of Proposed USEPA Nutrient Criteria Guidance Documents for AMSA:** The USEPA released separate proposed Nutrient Criteria Guidance documents on Lakes/Reservoirs, Rivers/Streams, and Estuaries/ Coastal Waters during 1999 and 2000. Mr. Thuman completed a technical review of these documents and provided assistance in the preparation of AMSA (now NACWA) comments and in negotiations with the USEPA. Example waterbodies were identified within USEPA eco-regions where the proposed criteria methods appear to produce criteria at odds with the water quality endpoints (e.g., phytoplankton, periphyton biomass, turbidity, and/or DO). This may be due to exogenous or environmental factors other than the nutrients themselves and the review was completed in order to highlight potential problems with the proposed Nutrient Criteria. As an alternative, specific waterbodies were selected for which data existed to estimate the impact that the proposed Nutrient Criteria may have on wastewater treatment and on additional treatment costs. He also investigated the general relationships between biological and nutrient conditions relative to biocriteria values and other accepted biological endpoints.

**Middle River Watershed Water Quality Management Plan, MD:** Project Manager for the development of a water quality model of the Middle River near Baltimore, MD. The model was used to assess water quality impacts associated with nonpoint source stormwater pollution, and recommended BMPs for stormwater discharges to the estuarine system. Assisted the County in identifying and evaluating nonpoint source stormwater pollution management measures for the reduction of nonpoint source pollution and water dependent uses in the estuarine system and provided a watershed restoration framework for the County's Capital Improvement Program. The model developed included a three-dimensional hydrodynamic model to determine the estuarine circulation patterns and a water quality model

associated with stormwater discharges in the basin for nutrients, suspended sediments and metals.

**Trail Creek Watershed TMDL, IN:** Project Manager for the development of an E. coli TMDL of Trail Creek, a tributary to Lake Michigan located in northwestern Indiana near Michigan City. This study involved the development of a watershed model (GWLF) and receiving water quality model (WASP6) for properly representing the sources, fate and transport of E. coli in the Trail Creek watershed. Ultimately, these models were used to determine the loads necessary to achieve the water quality standards in the creek. Participated in stakeholder meetings to present and discuss the various components involved in the development of the TMDL.

**San Joaquin River (SJR) DO TMDL Development, Stockton, CA:** Project Director for the development of a three-dimensional, water quality model of the SJR and Deep Water Ship Channel (Port of Stockton) to develop DO TMDLs for the California Bay Delta Authority (CBDA). The water quality model consists of an eutrophication model coupled with a sediment flux sub-model capable of analyzing vertical and intra-tidal fluctuations of DO. The coupled sediment flux sub-model provided the ability to assess the impact of algae and organic matter loading on DO levels in the SJR. In addition, upstream water quality projections were completed to assess the effect of upstream flows management and instream DO injection in the DWSC. A web-based post-processor was developed to allow stakeholders access to model output via an interactive GIS-based web browser.

**TMDL Development for the Rio Grande de Loiza and Rio La Plata Watersheds, Puerto Rico:** Project Director for TMDL development for PRASA and USEPA Region 2 to support the Watershed Stewardship Program for two watersheds in Puerto Rico to begin the process of studying the causes of water quality impairments and to develop solutions to improve the water quality of Puerto Rico waterbodies. Included in these location specific strategies has been the identification of the water quality problems and sources of these problems, development of water quality models that provide insight into these problems, and their causes and cures. The involvement of the various watershed stakeholders was incorporated as well to ensure that their issues are considered, their support for various strategies garnered, and that a foundation for a lasting support of the program established. The major pollutants of concern in these two watersheds are fecal coliform, total phosphorus related to eutrophication issues in downstream reservoirs, dissolved oxygen (DO) and metals (e.g., copper, selenium).

**Diffuser Design and Mixing Zone Development for the Packaging Corporation of America Discharge to Lake Michigan:** Project Director for a diffuser design study to improve mixing and dilution of the mill discharge to Lake Michigan near Filer City, MI. The current outfall is located close to the shoreline and at times causes aesthetic issues associated with effluent color. A new submerged diffuser was designed, located further off-shore, permitted, installed and put into operation to solve the aesthetic issues associated with

the effluent color.

**Diffuser Design and Mixing Zone Development for DuPont (Delaware River):** Project Director for a diffuser design study to improve mixing and dilution of the discharge in the tidal Delaware River. The current shoreline discharge achieves little mixing and a TIE/TRE study indicated that additional mixing and dilution were required to reduce effluent toxicity in the river. The near-field model, CORMIX, was used to assess various multi-port diffuser configurations so that mixing/dilution were optimized given regulatory mixing zone size constraints. The near-field modeling and mixing zone effort were used as part of NPDES permit negotiations with the regulatory agencies.

**Mixing Zone Study for the Rockwood Pigments Discharge to the Mississippi River, MO:** Project Manager for an outfall dilution and mixing zone study to assess the dilution of a surface discharge (above the river surface at low flow) for permitting support. The mixing zone was developed for un-ionized ammonia that included the effects of pH blending and near-field turbulent mixing (CFD modeling).

**Kinnura Bay Diffuser Design and Mixing Zone Study, Japan:** Project Manager for the conceptual diffuser design of the relocation of the Pfizer discharge in Kinnura Bay. The diffuser models CORMIX and PLUMES were used to analyze initial mixing for the proposed diffuser. In addition, a far field hydrodynamic model was developed to assess far field mixing and to account for the buildup of effluent constituents in bay water entrained during initial mixing from the diffuser.

**Evaluation of a Mixing Zone Analysis for Papermill Pond, CT:** Project Engineer for a study to evaluate compliance with a Connecticut DEP proposed mixing zone for a planned thermal discharge to Papermill Pond. The CORMIX model was successfully calibrated for an existing thermal discharge to Papermill Pond. The CORMIX model was then used to calculate whether the new thermal discharge would produce a delta 400F temperature increase beyond limits of the mixing zone established by CTDEP.

**Evaluation of Recirculation of a Proposed Thermal Discharge Effluent to the Intake Water:** Project Manager to compute initial dilution for a proposed thermal discharge from the Iliyan Power Plant in the Philippines. CORMIX was used to calculate temperature increases in the vicinity of the effluent diffuser. The results were incorporated in a far field hydrodynamic model to compute ambient water temperature at the power plant intake.

**Modeling Analysis of a Proposed Thermal Discharge to Gowanus Bay, NY:** Project Manager for the evaluation of initial mixing of the thermal discharge for a variety of potential diffuser locations in Gowanus Bay. The CORMIX program was used to compute temperature increases in the vicinity of the proposed diffuser locations. A hydrodynamic model was used to compute far field temperature distributions and the temperature of water that was re-entrained in the vicinity of the diffuser. On the basis of this study, the shortest length of pipe that complied with state temperature criteria was determined.

### **Publications and Presentations**

Thuman, A.J., C. Fanelli, J. Hallden, R. Isleib, R. Rugabandana and W. Hunley, 2014. James River Overflow Model: GUI Development for Ease of Use. Water Environment Federation Technical Exhibition and Conference.

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Thuman, A.J., T.W. Gallagher and T.M. Morse, 2006. Jackson River Modeling: 50-Year Perspective. Journal of Environmental Engineering, Vol. 132, No. 9, p1051-1060.

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Di Toro, D.M. and A.J. Thuman, 2001. Guest Editorial - It Takes Skill to Make Music. Stormwater, The Journal for Surface Water Quality Professionals, July/August 2001.

Thuman, A.J., C. Magruder, K. Oriel, D. Lau, S. McLellan and E. Jensen, 2006. Evaluation of Bacteria Impacts on Beaches in Milwaukee: The Bacteria Source, Transport and Fate Study. ASCE World Environmental and Water Resources Congress. Omaha NE, May 22, 2006.

Thuman, A.J., 2005. Completing TMDLs in Coastal Watersheds: Important Considerations. Water Environment Federation TMDL Conference. Philadelphia PA, June 29, 2005.

Thuman, A.J., D.M. Di Toro, F.L. Hellweger, 2004. Assessment of PCB Contamination in the Delaware River Estuary - Decadal Scale Consistency Check. Water Environment Federation Technical Exhibition and Conference. New Orleans LA, October 6, 2004.

Thuman, A.J., C. Magruder, S. McLellan and D. Lau, 2004. Assessing Bacteria Source Impacts on Beaches: A Modeling Approach. Water Environment Federation Technical Exhibition and Conference. New Orleans LA, October 5, 2004.

### **Prior Testimony**

Prefiled Direct Testimony of Andrew Thuman on Behalf of Champlain VT, LLC to the State of Vermont Public Service Board. Related to potential water quality impacts and water quality modeling associated with the New England Clean Power Link cable installation in Lake Champlain. 12/8/2014.